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Redfish in NAFO Subarea 2 and Division 3K

by

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Abstract

With the implementation of the 200-mile fisheries zone in 1977, Canada has since accounted for most of the reported landings (more than 70%). Landings have dropped substantially since the mid-1980s, from an average of about 27,000 tons to the lowest reported at 2,700 tons in 1989. This decline was the result of a major redirection of effort to other fisheries for cost-effective reasons as well as a marketability problem due to parasites. Research survey data indicate recruitment has been poor since the year-classes of the early 1970s. Application of general production models have not been appropriate for providing yield estimates, because there is little contrast in the standardized catch rates over time. Analytical assessments of population size are hampered by insufficient catch-at-age data coupled with low fishing mortalities.

Résumé

Depuis la mise en oeuvre de la zone de pêche des 200 milles, en 1977, la plupart des débarquements déclarés sont survenus au Canada (plus de 70 %). Les prises ont sensiblement diminué depuis le milieu des années 1980, passant d'une moyenne d'environ 27 000 tonnes à un seuil de 2 700 tonnes en 1989. Cette chute est le résultat d'une massive ré-orientation de l'effort de pêche vers d'autres espèces, entreprise pour des raisons de rendement économique et également à cause des difficultés commerciales découlant de la présence de parasites. Les études réalisées révèlent que le recrutement a été faible depuis l'apparition des classes annuelles du début années 1970. Il a été impossible d'utiliser des modèles de production généraux pour établir des estimations adéquates du rendement, à cause des faibles différences dans les taux de prises chronologiques normalisés. L'insuffisance des données sur les prises selon l'âge et la faible mortalité due à la pêche rendent difficile l'évaluation analytique quantitative de la population.

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Description of the fishery

Historical nominal catches reported from this fishery have ranged from a low of 2,675 t in 1989 to a high of 186,857 t in 1959 (Table 1; Fig. 1). In the early 1980s, landings ranged from 14,000 t to 18,000 t. Subsequently, in the 1984-86 period, improved market conditions resulted in increased catches between 24,000 t and 29,000 t. Since 1986, landings have dropped about 10,000 t each year to the lovest reported from this fishery in 1989. A number of reasons for this, according to Canadian Sectors which have a directed fishery, is that (1) catch rate did not allow a cost-effective operation and, subsequently, effort was diverted to other redfish fisheries; and (2) complaints of sphyrion infestion and melanosis (a bacterial condition in the flesh). Market conditions also added to the decline, as well as no directed trips by Japan and USSR for the Resource Short Plant Program since 1988.

Canadá has been the major prosecutor of this fishery since the implementation of the 200-mile fisheries zone in 1977, frequently taking more than 70% of the reported landings (Table 2).

Catches from Div. 2GH have been less than 600 t since 1978 (Table 3a) and are generally taken from July to December. In Div. 2J (Table 3b), with the exception of 1982, catches have been less than 4,500 t since 1980 and are landed throughout the year with a tendency for a higher proportion in July to September.

Catches from Div. 3K have generally been greater than 50% of the total landings historically and greater than 80% in recent years (Table 1; Fig. 1) and are taken throughout the year (Table 3c).

A breakdown of catches by division and gear since 1976 indicate otter trawls to be the predominant gear (Table 4).

Data

Catch and weight at age

Commercial frequencies available from the 1989 fishery (Fig. 3 and 4) were combined by the method of Gavaris and Gavaris (1983), as outlined in Figure 5, and then converted into numbers at age using a single age/length key (Table 5). The weight-length relationships used were:

$$WT\ (males) = 0.01659\ FL^{2.9548}$$
$$WT\ (females) = 0.01372\ FL^{3.0210}$$

The predominant length range in the frequencies is 29-35 cm corresponding to the early 1970's year-classes. Historical catch at age and weight at age are shown in Tables 6 and 7.

Commercial catch rates

Catch and effort data were available for the period 1959-1985 from ICNAF/NAFO Statistical Bulletins and were combined with provisional data from the following: NAFO for 1988, the Zonal Interchange file (ZIFF) for 1988 for Scotia-Fundy and Gulf regions (Canada (M)), ZIFF for 1989, and from Statistics Branch of the Newfoundland Region for 1988 and 1989. Initially selected from this database were observations where redfish comprised more than 50% of the total catch and were, therefore, assumed to be redfish directed.

These data were used in a multiplicative model (Gavaris 1980) to derive a standardized catch rate series. A new category type, redfish as a percentage of total catch (PCT), was added to the model to evaluate its usefulness in explaining catch rate variability. Each observation was further identified as to which "percentage of total catch" category it belonged to. Five categories were arbitrarily established: ($> 50 \leq 60$); ($> 60 \leq 70$); ($> 70 \leq 80$); ($> 80 \leq 90$); and (> 90). In order to gain some insight on what impact the addition of such a category type to the model had on catch rate trends, a number of different formulations of the model were tried. In all runs, unweighted regressions were used, because the amount of pro-rating of effort before 1984 could not be determined. Catch/effort data less than 10 units were deleted prior to analysis. Any category except "year" with less than five observations in the total dataset was also eliminated.

The inclusion of the PCT category type increased the explained variation (r^2) in the catch rates by 15% (Tables 8 and 10). Relationships within each category type as reflected in the regression coefficients remained relatively unchanged. The same general trends were evident in catch rate series derived without (Table 9; Fig. 6) and with (Table 11; Fig. 7) the PCT category in the model.

Runs 3 to 6 involved using the data separately for each percentage category. Due to a lack of data for the ($> 50 \leq 60$) and ($> 60 \leq 70$) categories separately, these data were pooled. Runs 3 to 6 then correspond to the (> 90), ($> 80 \leq 90$), ($> 70 \leq 80$), and ($> 50 \leq 70$) categories. In every run, each category type was significant (Tables 12-15) except for the following:

Run	Effect (not significant)	P-value
3	Division	$.25 < P < .50$
5	CGT	$.10 < P < .25$
5	Division	$P > .75$
5	Year	$.10 < P < .25$
6	Division	$.25 < P < .50$
6	Year	$.05 < P < .10$

Partitioning the total dataset based on the category type PCT did not change basic relationships between categories where it was possible to compare relative fishing power within a category type across the datasets. For example, the fishing power of a Newfoundland TC4 OTB was always less than a Newfoundland TC5 OTB. The standardized catch rates from Runs 3 to 6 (Fig. 8-11) show much variability around the mean each year, especially for the pre-1978 data. Runs 3, 5, and 6 show a similar declining trend from the mid- to late-1960s. All the derived series show the same general trend from 1978 to 1989 - increasing to 1983 followed by a decline to 1989. What is also evident is an overall scaling up of the index as less bycatch is associated with the catch.

On the premise that the addition of the PCT category type to the model did not show a different trend from a model that did not include it, one final run was made without the 1974 data because these were considered anomalous. Results from a previous study (Atkinson and Power 1986) comparing catch rates derived in analyses that treated each division separately indicate something odd happened in Div. 3K, 3L, and 3N in this year (Fig. 12). Catch rate dropped substantially in Div. 3L concurrent with a substantial increase in Div. 3K and 3N from the 1973 value. The results of the final run (Table 16) show the regression is highly significant, explaining 53% of the variation in the data. All category types are highly significant with the exception of division which is marginally non-significant ($.05 < P < .10$). Estimated coefficients from the regression for each category (Table 16) show catch rates are generally higher during the first half of the year. Residual plots (Fig. 13) did not reveal any drastic outliers or signal that the model was inappropriate. Yearly effort, calculated from the standardized catch rates and reported catches, falls within a range of 1,500-17,000 hours since 1980 (Fig. 2). The standardized catch rate series (Table 17; Fig. 14) shows an increase from 1959 to 1964 followed by a decrease to the lowest rate on record in 1973. A period of stability occurred up until 1981. From 1981 to 1984, there was a steady increase followed by a decrease to 1989.

Research vessel survey data

Stratified-random surveys have been carried out in the fall in Div. 2J and 3K since 1977. Since coverage was not complete in all years, a multiplicative model was used to obtain estimates of mean number and weight for strata which were not covered in various surveys. The historical series of mean numbers and weights per standard tow from STRAP and the multiplicative analysis (Tables 18-21; Fig. 15-16) suggest a downward trend both in Div. 2J and Div. 3K. The very high values for Div. 2J in 1981 and Div. 3K in 1983 were the result of high catches for one set in stratum 228 and stratum 634 respectively. These strata get weighted heavily when calculating the division mean per tow. Mean numbers and weights by stratum for Div. 2GH (Tables 22 and 23) indicate the density in these more northern divisions is lower than in Div. 2J and 3K. However, the time series is discontinuous and of little value in tracking dynamics of the population.

Contour maps (Fig. 17) illustrate variable densities of redfish encountered during fall surveys in Div. 2J3K from 1978 to 1989. These maps suggest that, in some years, a large proportion of the fish moved out of the survey area. They show as well that, in some years, large concentrations of fish are at the borders of the surveyed area. One conclusion from these maps is that both the timing and the area surveyed may not be optimum to gain insight into the dynamics of this stock. Estimated total biomass (Table 24), calculated by the contouring method (Black pers. comm.) shows identical trends over time to those from STRAP (Fig. 18).

Length frequencies and numbers at age from the fall surveys (Fig. 19-28), expressed as number per thousand, indicate that recruitment has been relatively poor since the surveys began in 1977.

Estimation of stock parameters

Catch and effort data from the multiplicative model without the 1974 data were utilized in a non-equilibrium version of the Schaefer general production model (Rivard and Bledsoe 1978). The 1974 effort for the analysis was derived by dividing the catch by an average of the 1973 and 1975 catch rates. A number of runs were tried with catchability coefficient fixed at 5×10^{-6}, 7×10^{-6}, and 9×10^{-6}. In all cases where convergence criteria were met, estimates of maximum exploitable yield (MEY) were not significantly different from zero. The results are similar to the last assessment in which this model was used (Power and Atkinson 1987) because, basically, there was an addition of only three data points that were within the range of previous years in the series. It remains that because there is little contrast in the standardized catch rates over time, from a statistical point of view, that general production analyses are not appropriate.

Prognosis

The decline in catch rates in recent years may be indicative of a reduction in stock biomass or may be attributed to recent limited fishing effort. Density distribution maps contoured from survey data suggest that both the timing and coverage of these surveys may not be optimum to gain insight into the dynamics of this stock. Despite the reservations about the survey data as an index of stock abundance, there is a concern that recruitment has been poor since the year-classes of the early 1970s. If the stock were to experience good recruitment in the near future, it would still take about 10 years for this to be available to the fishery because of the relatively slow growth rate of redfish. No analysis is possible at present to determine where the current TAC of 35,000 t stands in relation to an appropriate target level. Catches of that magnitude may be detrimental if sustained for a period of time, given the long period of poor recruitment to the fishery.

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Table 1. Summary of nominal catches (t) of redfish in SA2 + Div. 3K.

Year	2G	2H	2J	3K	Total	TAC
1959	-	23	52,519	134,065	186,837[a]	
1960	-	56	82,800	46,861	129,773[a]	
1961	-	542	25,052	29,861	55,455	
1962	-	155	7,576	11,925	19,657[a]	
1963	245	16	5,873	17,510	23,644	
1964	120	938	16,001	23,044	50,154[a]	
1965	851	1,735	15,367	16,748	40,425[a]	
1966	197	4,678	9,135	18,720	32,730	
1967	24	3,327	13,699	9,112	26,162[a]	
1968	670	3,156	4,937	10,103	18,881[a]	
1969	55	180	5,838	13,785	19,883[a]	
1970	85	393	6,482	10,010	16,970	
1971	471	1,079	5,084	12,672	19,306	
1972	22	637	8,879	10,495	20,033	
1973	192	742	10,545	27,486	38,965	30,000
1974	85	429	5,943	23,688	30,145	30,000
1975	67	383	14,096	11,013	25,559	30,000
1976	89	1,606	14,412	9,858	25,965	30,000
1977	99	770	6,509	10,161	17,539	30,000
1978	29	554	11,804	16,759	29,146	30,000
1979	14	256	16,659	13,801	30,730	30,000
1980	2	47	4,423	10,047	14,519	35,000
1981	24	203	4,241	13,174	17,642	35,000
1982	-	583	7,048	10,352	17,983	35,000
1983	-	158	2,166	12,987	15,311	35,000
1984	49	81	2,329	21,230	23,689	35,000
1985	-	133	867	28,225	29,225	35,000
1986	-	69	3,456	23,360	27,019	35,000
1987[b]	-	16	3,212	15,283	18,511	35,000
1988[b]	8	28	992	5,908	6,936	35,000
1989[b]	-	-	62	2,108	2,675[c]	35,000
1990						35,000

[a]Totals include unallocated catch in Subarea 2.

[b]Provisional.

[c]Total includes 505 t that could not be separated by division.

Table 2. Nominal catches (t) of redfish in Subarea 2 + Division 3K by country and year.

Country	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988[a]	1989[a]
Can (N)	10,938	11,095	3,768	10,298	7,350	5,413	12,298	14,863	10,933	8,719	4,432	1,587
Can (M)	11,114	15,492	4,017	3,118	3,784	3,384	5,069	6,716	7,860	3,429	922	583
Cuba	-	43	-	-	-	-	-	-	-	-	-	-
DDR	2,909	543	1,102	720	425	626	485	101	134	378	-	-
Faroes	-	-	-	-	-	-	-	-	-	16	-	-
France (Metro)	22	3	7	-	9	-	2	9	5	3	-	-
FRG	157	68	148	-	180	77	111	204	63	65	-	-
Japan	255	-	9	4	2,662	-	1,218	3,471	4,178	2,127	698	-
Norway	-	-	1	-	-	-	-	-	1	-	-	-
Poland	625	302	870	635	24	1,406	366	66	297	41	36	1
Portugal	378	544	266	393	456	183	437	106	20	-	-	-
Spain	37	-	44	-	-	-	-	-	-	-	-	-
UK	26	62	79	-	20	-	13	-	-	-	-	-
USSR	2,685	2,578	4,208	2,474	3,073	3,722	3,690	3,689	3,528	3,733	848	483
EEC	-	-	-	-	-	-	-	-	-	-	-	21
Total	29,146	30,730	14,519	17,642	17,983	15,311	23,689	29,225	27,019	18,511	6,936	2,675

[a]Provisional.

Table 3a. Nominal catches (t) of redfish in Divisions 2GH by month and year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1978	224	1	-	-	-	-	5	55	33	9	98	158	583
1979	93	-	-	-	11	-	-	35	22	81	23	5	270
1980	9	-	10	-	1	-	1	-	14	12	-	2	49
1981	22	-	-	-	-	2	28	97	19	32	15	12	227
1982	33	-	-	-	-	29	-	1	300	5	106	109	583
1983	-	-	-	-	-	-	37	-	22	7	87	5	158
1984	-	-	-	-	-	-	-	74	6	14	20	16	130
1985	-	-	-	-	-	-	113	20	-	-	-	-	133
1986	-	-	-	-	-	-	6	59	1	-	3	-	69
1987	-	-	-	-	-	-	10	-	4	-	2	-	16
1988[a]	-	-	-	-	-	-	15	2	-	4	10	5	36
1989[a]	-	-	-	-	-	-	-	-	-	-	-	-	0

[a]Provisional.

Table 3b. Nominal catches (t) of redfish in Division 2J by month and year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1978	669	217	418	177	6	1	353	3,994	3,614	1,577	527	251	11,804
1979	137	277	36	-	20	68	2,026	4,452	6,071	3,336	204	32	16,659
1980	43	357	91	59	246	6	13	464	2,784	38	106	216	4,423
1981	206	65	75	12	-	29	1,398	1,886	11	55	114	390	4,241
1982	27	294	191	63	197	410	1,134	2,395	2,188	123	14	12	7,048
1983	37	225	96	93	-	34	403	269	41	18	250	700	2,166
1984	-	-	34	14	2	114	34	1,871	46	80	67	67	2,329
1985	-	-	-	2	-	27	482	296	15	35	-	10	867
1986	68	-	3	-	1	42	34	1,529	1,528	79	152	20	3,456
1987	154	277	276	184	8	82	3	1,380	153	458	118	119	3,212
1988[a]	27	12	99	44	50	1	-	24	368	256	1	110	992
1989[a]	24	3	-	1	1	3	-	5	-	-	11	14	62[b]

[a]Provisional.

[b]Canadian data only.

Table 3c. Nominal catches (t) of redfish in Division 3K by month and year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	214	1,624	754	382	245	347	3,699	1,103	1,180	377	163	73	10,161
1978	295	589	4,294	2,565	1,757	412	377	597	1,847	469	1,652	1,905	16,759
1979	134	954	1,874	1,800	1,747	951	450	2,107	1,431	2,073	115	165	13,801
1980	112	209	1,154	1,671	1,087	140	196	1,400	693	509	1,845	1,031	10,047
1981	139	342	501	1,085	630	3,405	3,212	1,998	713	120	416	613	13,174
1982	73	136	112	576	1,187	370	1,010	2,031	424	634	2,214	1,585	10,352
1983	447	1,073	2,558	1,354	972	751	627	3,772	532	548	40	313	12,987
1984	924	1,327	1,761	2,920	2,704	936	1,164	2,764	2,165	2,962	863	740	21,230
1985	1,534	2,378	2,609	2,669	2,061	1,675	1,612	4,961	2,500	1,547	1,717	2,962	28,225
1986	966	1,932	2,371	1,353	1,924	860	172	2,426	4,049	2,283	3,378	1,780	23,494
1987	369	357	522	1,413	732	1,150	945	1,001	2,323	2,134	1,202	3,135	15,283
1988[a]	496	390	415	236	395	408	226	431	758	1,432	547	174	5,908
1989[a]	23	97	223	53	231	96	179	369	302	447	53	35	2,108[b]

[a]Provisional.

[b]Canadian data only.

Table 4. Breakdown of catches by gear type for redfish in SA2 + 3K.

Year	2GH				2J				3K				Totals
	Bottom trawl	MW trawl	Gillnets	Misc.	Bottom trawl	MW trawl	Gillnets	Misc.	Bottom trawl	MW trawl	Gillnets	Misc.	
1976	1,535	160	-	-	11,857	2,555	-	-	8,706	901	247	4	25,965
1977	869	-	-	-	5,894	615	-	-	9,345	658	158	-	17,539
1978	582	1	-	-	10,028	1,776	-	-	14,695	1,901	163	-	29,146
1979	255	15	-	-	14,360	2,299	-	-	9,316	4,103	382	-	30,730
1980	49	-	-	-	4,350	5	68	-	9,804	-	243	-	14,519
1981	227	-	-	-	4,236	-	5	-	12,630	250	294	-	17,642
1982	583	-	-	-	7,036	-	12	-	7,366	2,876	110	-	17,983
1983	158	-	-	-	2,166	-	-	-	12,872	114	1	-	15,311
1984	130	-	-	-	2,316	-	13	-	20,751	352	127	-	23,689
1985	133	-	-	-	856	-	11	-	27,818	306	101	-	29,225
1986	69	-	-	-	3,209	227	-	20	22,073	1,319	102	-	27,019
1987	16	-	-	-	3,190	7	15	-	14,810	423	50	-	18,511
1988[a]	30	6	-	-	991	-	1	-	5,829	1	78	-	6,936[b]
1989[a]	-	-	-	-	62	-	-	-	2,008	1	98	1	2,170[b]

[a]Provisional.
[b]Canadian data only.

Table 5. Estimated numbers of redfish caught at age ('000) (including their average weight and length) in the commercial fishery in Subarea 2 and Div. 3K in 1989.

	AVERAGE		CATCH		
AGE	WEIGHT	LENGTH	MEAN	STD. ERR.	C. V.
* 6	0.060	16.000	1	0.00	0.00
* 7	0.118	20.090	3	1.41	0.53
* 8	0.155	21.981	62	9.30	0.15
9	0.185	23.299	100	13.69	0.14
10	0.214	24.478	86	14.17	0.16
11	0.242	25.534	119	18.03	0.15
12	0.270	26.455	141	20.76	0.15
13	0.294	27.251	206	28.93	0.14
14	0.331	28.327	233	33.71	0.14
15	0.367	29.321	399	47.82	0.12
16	0.401	30.204	562	57.70	0.10
17	0.457	31.485	483	56.17	0.12
18	0.514	32.752	476	54.52	0.11
19	0.548	33.430	364	48.06	0.13
20	0.587	34.209	349	45.78	0.13
21	0.634	35.085	289	39.87	0.14
22	0.702	36.302	146	28.42	0.20
23	0.698	36.176	134	26.42	0.20
24	0.783	37.573	109	21.62	0.20
25	0.781	37.587	116	21.67	0.19
26	0.808	38.064	55	14.28	0.26
27	0.837	38.469	63	15.77	0.25
28	0.903	39.414	61	13.66	0.23
29	0.823	38.506	78	18.39	0.24
30	1.099	41.912	185	20.43	0.11

FOR THE AGES FLAGGED BY * THERE WAS AN AGE LENGTH KEY WITH ONLY ONE AGE DETERMINATION FOR SOME LENGTH. SINCE THE VARIANCE FORMULA HAS N-1 IN THE DENOMINATOR IT CANNOT BE EVALUATED FOR THIS LENGTH. CONSEQUENTLY THIS VARIANCE COMPONENT IS NOT INCLUDED IN THE VARIANCE FOR THE FLAGGED AGES. THIS IS GENERALLY NOT A SERIOUS PROBLEM SINCE IT OCCURS WHEN FEW FISH ARE CAUGHT AT THAT LENGTH.

Table 6. Estimated numbers of redfish caught at age ('000) in Subarea 2 and Div. 3K, 1976-1989.

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	7	22	4	240	28	44	1	1	2	0	2	2
7	30	102	400	2159	301	199	224	13	14	48	36	24
8	136	219	1241	5678	1669	607	998	351	60	220	302	165
9	1265	612	3297	8798	996	1398	2252	955	1058	680	599	548
10	2067	843	4071	9251	869	1819	3678	1155	3124	3701	1693	729
11	3866	1569	4495	6700	839	1536	3920	1271	3713	6555	2696	1095
12	5580	1930	5806	4011	1031	1047	3967	2051	3982	7717	4479	1898
13	7818	2241	6207	7374	1549	1348	4122	2090	5015	8971	6332	2661
14	8652	3315	6267	6646	1889	1409	3479	2352	4591	7829	8003	3720
15	8615	3162	5265	6571	2050	2138	3765	1855	4472	6458	6569	4716
16	2700	2776	5331	6075	1727	1887	3135	1624	4002	5068	4533	4537
17	1826	2504	3969	5544	1753	2302	3052	1641	2666	4305	4345	4140
18	946	1812	2250	1796	1032	1920	2049	1398	2700	4080	3684	2770
19	757	1778	1488	1241	793	1470	1537	1206	1693	2757	2745	2214
20	1128	1638	1495	1391	10058	1308	1044	912	1851	1495	2106	1549
21	968	895	1084	1412	669	1019	1060	956	1671	1548	1683	1176
22	885	940	950	789	532	1001	627	710	1365	1140	1327	868
23	1100	555	591	573	503	1093	498	613	1044	990	1066	817
24	1005	618	883	599	748	1004	517	823	1183	837	850	731
25	684	598	828	930	521	828	324	771	956	681	694	661
26	678	514	746	569	524	903	369	560	954	824	802	482
27	512	435	509	590	505	540	341	597	758	584.	695	457
28	632	418	535	589	389	749	256	565	806	621	653	563
29	284	200	139	283	415	580	226	492	652	533	597	467

	1988	1989
6	0	1
7	22	3
8	103	62
9	153	100
10	263	86
11	340	119
12	737	141
13	905	206
14	1261	233
15	1928	399
16	1993	562
17	1157	483
18	1188	476
19	1115	364
20	616	349
21	513	289
22	360	146
23	316	134
24	235	109
25	195	116
26	244	55
27	193	63
28	164	61
29	115	78

Table 7. Estimated weight at age (kg.) of redfish caught in Subarea 2 and Div. 3K, 1976-1989.

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	0.103	0.103	0.103	0.103	0.110	0.088	0.103	0.100	0.100	0.082	0.064	0.060
7	0.135	0.135	0.135	0.135	0.170	0.115	0.141	0.140	0.118	0.118	0.110	0.129
8	0.169	0.169	0.169	0.169	0.184	0.158	0.173	0.160	0.170	0.138	0.154	0.152
9	0.205	0.205	0.205	0.205	0.217	0.198	0.209	0.190	0.201	0.191	0.187	0.185
10	0.243	0.243	0.243	0.243	0.240	0.220	0.253	0.220	0.228	0.217	0.216	0.214
11	0.282	0.282	0.282	0.282	0.279	0.241	0.269	0.250	0.246	0.238	0.233	0.237
12	0.322	0.322	0.322	0.322	0.287	0.277	0.297	0.280	0.273	0.264	0.262	0.264
13	0.362	0.362	0.362	0.362	0.314	0.317	0.327	0.300	0.305	0.293	0.293	0.297
14	0.403	0.403	0.403	0.403	0.361	0.352	0.356	0.330	0.353	0.317	0.329	0.332
15	0.443	0.443	0.443	0.443	0.418	0.397	0.406	0.370	0.373	0.358	0.356	0.361
16	0.482	0.482	0.482	0.482	0.463	0.445	0.450	0.410	0.403	0.395	0.401	0.402
17	0.521	0.521	0.521	0.521	0.534	0.493	0.489	0.480	0.443	0.439	0.451	0.437
18	0.559	0.559	0.559	0.559	0.566	0.544	0.564	0.520	0.477	0.471	0.506	0.493
19	0.596	0.596	0.596	0.596	0.596	0.593	0.598	0.570	0.508	0.505	0.510	0.535
20	0.631	0.631	0.631	0.631	0.674	0.629	0.646	0.600	0.568	0.536	0.561	0.587
21	0.665	0.665	0.665	0.665	0.651	0.703	0.695	0.640	0.633	0.605	0.603	0.593
22	0.698	0.698	0.698	0.698	0.747	0.733	0.707	0.670	0.678	0.629	0.623	0.653
23	0.730	0.730	0.730	0.730	0.788	0.757	0.795	0.720	0.699	0.719	0.672	0.691
24	0.759	0.759	0.759	0.759	0.754	0.809	0.790	0.740	0.741	0.761	0.732	0.754
25	0.788	0.788	0.788	0.788	0.769	0.822	0.851	0.800	0.765	0.799	0.786	0.789
26	0.815	0.815	0.815	0.815	0.946	0.843	0.860	0.800	0.830	0.822	0.804	0.801
27	0.841	0.841	0.841	0.841	0.931	0.933	0.873	0.830	0.827	0.851	0.815	0.838
28	0.866	0.866	0.866	0.866	0.922	0.918	0.880	0.820	0.860	0.840	0.827	0.822
29	0.889	0.889	0.889	0.889	0.999	0.891	0.904	0.900	0.873	0.862	0.836	0.886

	1988	1989
6	0.060	0.060
7	0.128	0.118
8	0.143	0.155
9	0.184	0.185
10	0.206	0.214
11	0.231	0.242
12	0.262	0.270
13	0.292	0.294
14	0.329	0.331
15	0.369	0.367
16	0.415	0.401
17	0.460	0.457
18	0.508	0.514
19	0.535	0.548
20	0.570	0.587
21	0.603	0.634
22	0.638	0.702
23	0.725	0.698
24	0.768	0.783
25	0.807	0.781
26	0.824	0.808
27	0.901	0.837
28	0.891	0.903
29	0.911	0.823

Table 8. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data without the PCT category type (RUN 1, see text).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.615
MULTIPLE R SQUARED..... 0.378

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	5.790E1	5.790E1	
REGRESSION	70	1.127E2	1.609E0	6.008
TYPE 1	27	4.354E1	1.613E0	6.021
TYPE 2	11	1.573E1	1.430E0	5.340
TYPE 3	2	1.711E0	8.556E-1	3.194
TYPE 4	30	3.255E1	1.085E0	4.051
RESIDUALS	692	1.853E2	2.678E-1	
TOTAL	763	3.559E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3125	INTERCEPT	0.586	0.151	763
2	8				
3	31				
5	59				
1	2125	1	0.068	0.139	20
	2154	2	-0.155	0.226	6
	2155	3	0.167	0.169	12
	3124	4	-0.285	0.104	31
	3155	5	0.264	0.119	28
	11115	6	-0.801	0.208	12
	11116	7	-0.462	0.219	9
	11125	8	-0.135	0.163	12
	11126	9	-0.563	0.166	19
	11127	10	-0.211	0.140	19
	12105	11	-0.253	0.195	12
	12106	12	0.011	0.173	18
	14124	13	0.798	0.207	7
	14125	14	-0.174	0.192	8
	14126	15	0.272	0.124	22
	14127	16	0.034	0.208	7
	16127	17	-0.653	0.101	94
	17116	18	0.071	0.265	7
	17127	19	-0.114	0.213	7
	20114	20	-1.033	0.177	16
	20116	21	-0.696	0.189	17
	20126	22	-0.285	0.272	5
	20127	23	-0.153	0.082	91
	20157	24	0.175	0.179	10
	27124	25	-0.154	0.184	9
	27125	26	0.145	0.068	95
	27126	27	0.432	0.240	5

Table 8. (continued)

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
2	1	28	0.287	0.127	21
	2	29	0.327	0.122	24
	3	30	0.204	0.094	47
	4	31	0.234	0.094	54
	5	32	0.022	0.088	60
	6	33	-0.279	0.085	63
	7	34	-0.061	0.082	71
	9	35	0.048	0.075	91
	10	36	-0.153	0.078	86
	11	37	-0.155	0.084	72
	12	38	-0.046	0.087	64
3	22	39	-0.121	0.116	24
	23	40	0.097	0.047	216
5	60	41	-0.302	0.190	12
	61	42	0.163	0.269	5
	62	43	0.194	0.251	6
	63	44	0.298	0.197	20
	64	45	0.312	0.196	19
	65	46	0.178	0.196	19
	66	47	-0.006	0.221	11
	67	48	0.005	0.189	34
	68	49	-0.259	0.224	12
	69	50	-0.644	0.251	6
	70	51	-0.346	0.260	5
	71	52	-0.023	0.221	9
	72	53	-0.164	0.239	9
	73	54	-0.714	0.211	10
	74	55	0.043	0.268	9
	75	56	-0.469	0.254	8
	76	57	-0.414	0.176	23
	77	58	-0.304	0.161	34
	78	59	-0.405	0.155	61
	79	60	-0.489	0.156	47
	80	61	-0.320	0.154	34
	81	62	-0.477	0.159	34
	82	63	-0.245	0.157	39
	83	64	-0.046	0.171	25
	84	65	0.138	0.157	40
	85	66	-0.103	0.157	45
	86	67	-0.316	0.152	60
	87	68	-0.007	0.154	46
	88	69	-0.415	0.163	31
	89	70	-0.214	0.210	11

Table 9. Predicted catch rate series for RUN 1 (see text).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1959	0.5857	0.0228	2.031	0.305	186837	92002
1960	0.2834	0.0364	1.491	0.282	129773	87054
1961	0.7490	0.0746	2.330	0.625	55455	23803
1962	0.7792	0.0592	2.420	0.580	19657	8123
1963	0.8838	0.0286	2.728	0.459	23644	8667
1964	0.8978	0.0288	2.766	0.467	50154	18131
1965	0.7635	0.0286	2.419	0.407	40425	16712
1966	0.5795	0.0393	2.002	0.393	32730	16352
1967	0.5909	0.0263	2.038	0.328	26162	12838
1968	-0.3263	0.0391	1.554	0.304	18881	12150
1969	-0.0588	0.0569	1.048	0.247	19883	18973
1970	0.2400	0.0642	1.408	0.351	16970	12056
1971	0.5631	0.0414	1.967	0.397	19306	9815
1972	-0.4218	0.0456	1.704	0.360	20033	11755
1973	-0.1287	0.0325	0.989	0.177	38965	39390
1974	0.6286	0.0615	2.079	0.508	30145	14500
1975	0.1164	0.0533	1.251	0.285	25559	20433
1976	0.1714	0.0196	1.344	0.187	25965	19319
1977	0.2815	0.0144	1.505	0.180	17539	11658
1978	0.1806	0.0109	1.362	0.142	29146	21393
1979	0.0962	0.0106	1.252	0.128	30730	24537
1980	0.2658	0.0137	1.481	0.173	14519	9800
1981	0.1087	0.0118	1.267	0.137	17642	13921
1982	0.3405	0.0109	1.599	0.167	17983	11249
1983	0.5396	0.0151	1.947	0.239	15311	7865
1984	0.7242	0.0109	2.346	0.244	23689	10096
1985	0.6887	0.0098	2.266	0.224	29225	12899
1986	0.2700	0.0086	1.492	0.138	27019	18115
1987	0.5791	0.0100	2.030	0.203	18511	9117
1988	0.1707	0.0125	1.348	0.150	6936	5146
1989	0.3719	0.0272	1.636	0.268	2675	1635

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.163

Table 10. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data including the PCT category type (RUN 2, see text).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.729
MULTIPLE R SQUARED..... 0.531

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	5.790E1	5.790E1	
REGRESSION	74	1.582E2	2.138E0	10.525
TYPE 1	27	3.320E1	1.230E0	6.052
TYPE 2	11	2.675E1	2.432E0	11.970
TYPE 3	2	1.030E0	5.148E-1	2.534
TYPE 4	4	4.558E1	1.139E1	56.088
TYPE 5	30	2.591E1	8.637E-1	4.251
RESIDUALS	688	1.398E2	2.032E-1	
TOTAL	763	3.559E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3125	INTERCEPT	0.598	0.133	763
2	8				
3	31				
4	95				
5	59				
1	2125	1	0.168	0.121	20
	2154	2	-0.131	0.198	6
	2155	3	0.310	0.148	12
	3124	4	-0.281	0.091	31
	3155	5	0.126	0.104	28
	11115	6	-0.739	0.181	12
	11116	7	-0.377	0.191	9
	11125	8	-0.131	0.142	12
	11126	9	-0.315	0.145	19
	11127	10	-0.151	0.123	19
	12105	11	-0.352	0.170	12
	12106	12	-0.219	0.152	18
	14124	13	0.666	0.180	7
	14125	14	-0.262	0.168	8
	14126	15	0.246	0.108	22
	14127	16	0.029	0.181	7
	16127	17	-0.396	0.090	94
	17116	18	0.243	0.235	7
	17127	19	-0.011	0.185	7
	20114	20	-1.151	0.154	16
	20116	21	-0.723	0.164	17
	20126	22	-0.295	0.237	5
	20127	23	0.027	0.073	91
	20157	24	0.174	0.156	10
	27124	25	-0.161	0.161	9
	27125	26	0.105	0.060	95
	27126	27	0.309	0.210	5

Table 10. (continued)

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
2	1	28	0.451	0.111	21
	2	29	0.580	0.107	24
	3	30	0.415	0.083	47
	4	31	0.420	0.083	54
	5	32	0.182	0.077	60
	6	33	-0.224	0.074	63
	7	34	-0.045	0.071	71
	9	35	0.011	0.066	91
	10	36	-0.127	0.068	86
	11	37	-0.077	0.073	72
	12	38	0.039	0.076	64
3	22	39	0.027	0.102	24
	23	40	0.092	0.041	216
4	55	41	-0.922	0.069	70
	65	42	-0.688	0.065	79
	75	43	-0.420	0.057	108
	85	44	-0.197	0.044	198
5	60	45	0.033	0.167	12
	61	46	-0.010	0.235	5
	62	47	0.214	0.220	6
	63	48	0.481	0.172	20
	64	49	0.463	0.172	19
	65	50	0.227	0.171	19
	66	51	0.315	0.194	11
	67	52	0.285	0.166	34
	68	53	-0.182	0.195	12
	69	54	-0.178	0.221	6
	70	55	-0.004	0.228	5
	71	56	-0.003	0.193	9
	72	57	-0.208	0.208	9
	73	58	-0.326	0.186	10
	74	59	0.281	0.235	9
	75	60	-0.274	0.222	8
	76	61	-0.254	0.154	23
	77	62	-0.171	0.141	34
	78	63	-0.315	0.135	61
	79	64	-0.280	0.137	47
	80	65	-0.238	0.134	34
	81	66	-0.236	0.139	34
	82	67	-0.058	0.138	39
	83	68	0.033	0.149	25
	84	69	0.258	0.137	40
	85	70	0.197	0.137	45
	86	71	-0.219	0.133	60
	87	72	0.047	0.134	46
	88	73	-0.307	0.142	31
	89	74	-0.117	0.183	11

Table 11. Predicted catch rate series for RUN 2 (see text).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1959	0.5980	0.0176	1.996	0.264	186837	93623
1960	0.6306	0.0284	2.051	0.343	129773	63287
1961	0.5881	0.0567	1.938	0.455	55455	28621
1962	0.8117	0.0452	2.437	0.512	19657	8066
1963	1.0794	0.0221	3.222	0.477	23644	7338
1964	1.0611	0.0228	3.162	0.475	50154	15859
1965	0.8254	0.0220	2.500	0.369	40425	16173
1966	0.9127	0.0306	2.716	0.471	32730	12052
1967	0.8834	0.0207	2.650	0.380	26162	9871
1968	0.4162	0.0303	1.653	0.286	18881	11420
1969	0.4205	0.0445	1.649	0.344	19883	12060
1970	0.5942	0.0496	1.956	0.430	16970	8674
1971	0.5953	0.0319	1.976	0.350	19306	9771
1972	0.3897	0.0347	1.607	0.297	20033	12470
1973	0.2720	0.0257	1.434	0.229	38965	27163
1974	0.8788	0.0472	2.603	0.560	30145	11579
1975	0.3238	0.0407	1.499	0.300	25559	17046
1976	0.3444	0.0151	1.550	0.190	25965	16747
1977	0.4268	0.0114	1.687	0.180	17539	10398
1978	0.2834	0.0085	1.464	0.135	29146	19914
1979	0.3176	0.0086	1.514	0.140	30730	20293
1980	0.3604	0.0107	1.579	0.163	14519	9195
1981	0.3616	0.0095	1.582	0.154	17642	11153
1982	0.5399	0.0087	1.891	0.176	17983	9508
1983	0.6309	0.0119	2.068	0.225	15311	7403
1984	0.8559	0.0087	2.594	0.242	23689	9132
1985	0.7952	0.0077	2.443	0.215	29225	11965
1986	0.3793	0.0068	1.612	0.133	27019	16759
1987	0.6452	0.0078	2.102	0.185	18511	8805
1988	0.2911	0.0100	1.474	0.147	6936	4706
1989	0.4813	0.0213	1.772	0.258	2675	1509

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.144

Table 12. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data using only the 95% PCT category data (RUN 3, see text).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R,..... 0.702
MULTIPLE R SQUARED,..... 0.493

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.071E1	6.071E1	
REGRESSION	57	4.387E1	7.696E-1	3.673
TYPE 1	17	1.432E1	8.426E-1	4.022
TYPE 2	10	4.868E0	4.868E-1	2.324
TYPE 3	1	1.689E-1	1.689E-1	0.806
TYPE 4	29	1.054E1	3.634E-1	1.735
RESIDUALS	215	4.505E1	2.095E-1	
TOTAL	273	1.496E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3125	INTERCEPT	0.769	0.283	273
2	8				
3	31				
5	59				
1	2125	1	0.198	0.208	7
	2155	2	0.149	0.241	5
	3124	3	-0.184	0.138	15
	3155	4	0.034	0.144	21
	11115	5	-0.606	0.434	5
	11125	6	-0.099	0.219	6
	11127	7	-0.209	0.216	9
	12106	8	-0.154	0.351	8
	14124	9	0.707	0.207	6
	14125	10	-0.345	0.206	6
	14126	11	0.498	0.147	14
	16127	12	-0.682	0.175	17
	20114	13	-1.173	0.285	11
	20116	14	-0.979	0.303	11
	20127	15	-0.489	0.170	15
	20157	16	-0.047	0.213	6
	27125	17	-0.002	0.095	44
2	1	18	0.547	0.230	5
	3	19	0.145	0.249	5
	4	20	0.566	0.180	13
	5	21	0.085	0.153	18
	6	22	-0.211	0.140	18
	7	23	-0.071	0.123	27
	9	24	0.037	0.101	51
	10	25	-0.070	0.110	42
	11	26	-0.043	0.127	28
	12	27	-0.004	0.137	21

Table 12. (continued)

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
3	23	28	0.066	0.074	77
5	60	29	0.342	0.567	1
	61	30	-0.054	0.277	5
	62	31	-0.245	0.322	3
	63	32	0.460	0.388	3
	64	33	0.229	0.612	1
	65	34	-0.097	0.352	8
	66	35	-0.349	0.627	1
	67	36	-0.338	0.479	6
	68	37	-0.406	0.508	2
	70	38	-0.347	0.506	1
	71	39	0.293	0.405	2
	72	40	-0.566	0.570	1
	73	41	-0.467	0.552	1
	74	42	0.514	0.447	2
	75	43	-0.590	0.433	2
	76	44	-0.088	0.303	10
	77	45	-0.448	0.320	8
	78	46	-0.308	0.283	28
	79	47	-0.295	0.295	16
	80	48	-0.062	0.284	12
	81	49	-0.426	0.314	8
	82	50	-0.193	0.288	16
	83	51	-0.129	0.321	7
	84	52	0.207	0.295	14
	85	53	0.054	0.288	18
	86	54	-0.333	0.274	33
	87	55	-0.173	0.279	29
	88	56	-0.636	0.298	12
	89	57	-0.123	0.361	4

Table 13. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data using only the 85% PCT category data (RUN 4, see text).

ANALYSIS OF VARIANCE

MULTIPLE R..... 0.779
MULTIPLE R SQUARED..... 0.607

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	3.263E1	3.263E1	
REGRESSION	41	2.700E1	6.586E-1	4.141
TYPE 1	8	3.318E0	4.148E-1	2.608
TYPE 2	11	7.273E0	6.612E-1	4.157
TYPE 3	1	2.420E0	2.420E0	15.217
TYPE 4	21	7.853E0	3.740E-1	2.351
RESIDUALS	110	1.749E1	1.590E-1	
TOTAL	152	7.713E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3125	INTERCEPT	0.201	0.238	152
2	8				
3	31				
5	59				
1	2125	1	-0.006	0.249	5
	3124	2	-0.459	0.193	6
	3155	3	0.063	0.218	5
	12106	4	0.094	0.440	10
	14126	5	-0.417	0.224	5
	16127	6	-0.395	0.225	12
	20127	7	0.116	0.148	23
	27125	8	0.141	0.101	31
2	1	9	0.200	0.219	5
	2	10	0.157	0.200	7
	3	11	0.396	0.154	12
	4	12	0.380	0.160	12
	5	13	0.355	0.150	14
	6	14	-0.344	0.144	18
	7	15	-0.193	0.148	13
	9	16	-0.176	0.145	14
	10	17	-0.213	0.179	10
	11	18	-0.372	0.177	9
	12	19	0.008	0.165	12
3	23	20	0.402	0.103	43
5	63	21	0.389	0.389	2
	64	22	0.250	0.395	5
	65	23	0.494	0.386	2
	66	24	0.539	0.541	2
	67	25	0.524	0.491	5
	71	26	-0.167	0.433	1
	73	27	-0.232	0.376	2
	76	28	-0.650	0.365	2
	77	29	-0.059	0.247	6
	78	30	-0.044	0.268	9
	79	31	-0.253	0.245	12
	80	32	-0.002	0.236	8
	81	33	-0.016	0.249	8
	82	34	0.029	0.246	9
	83	35	0.439	0.234	9
	84	36	0.597	0.227	15
	85	37	0.371	0.241	9
	86	38	0.297	0.249	9
	87	39	0.342	0.234	11
	88	40	-0.026	0.224	12
	89	41	0.095	0.277	6

Table 14. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data using only the 75% PCT category data (RUN 5, see text).

ANALYSIS OF VARIANCE

MULTIPLE R..... 0.852
MULTIPLE R SQUARED..... 0.725

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.728E0	1.728E0	
REGRESSION	39	1.313E1	3.368E-1	2.096
TYPE 1	5	1.290E0	2.581E-1	1.606
TYPE 2	8	4.249E0	5.311E-1	3.306
TYPE 3	2	8.325E-3	4.163E-3	0.026
TYPE 4	24	5.299E0	2.208E-1	1.374
RESIDUALS	31	4.980E0	1.606E-1	
TOTAL	71	1.984E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3125	INTERCEPT	0.236	0.380	71
2	8				
3	31				
5	59				
1	3124	1	-0.431	0.289	5
	16127	2	-0.655	0.329	20
	17116	3	0.902	0.580	5
	20127	4	-0.157	0.248	16
	27125	5	-0.131	0.203	13
2	3	6	0.955	0.287	10
	4	7	1.078	0.320	5
	5	8	0.394	0.281	6
	6	9	0.012	0.270	9
	7	10	0.157	0.214	10
	9	11	0.086	0.250	7
	10	12	-0.410	0.257	7
	12	13	0.324	0.302	7
3	22	14	0.021	0.311	5
	23	15	0.034	0.148	22
5	62	16	0.686	0.593	1
	63	17	0.086	0.513	2
	64	18	0.533	0.411	8
	65	19	0.270	0.528	3
	66	20	0.142	0.621	1
	67	21	0.129	0.621	1
	70	22	0.467	0.416	2
	71	23	0.055	0.484	2
	73	24	0.033	0.569	1
	74	25	-0.886	0.713	3
	76	26	-1.624	0.735	1
	77	27	0.208	0.366	3
	78	28	-1.311	0.472	3
	79	29	-0.498	0.390	6
	80	30	-0.758	0.422	4
	81	31	-0.297	0.368	4
	82	32	-0.114	0.427	4
	83	33	-0.227	0.476	2
	84	34	-0.066	0.438	3
	85	35	0.062	0.345	6
	86	36	-0.395	0.401	5
	87	37	-0.193	0.498	1
	88	38	0.467	0.537	1
	89	39	-0.550	0.579	1

Table 15. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data using only the 55% and 65% PCT category data (RUN 6, see text).

MULTIPLE R,..... 0.762
MULTIPLE R SQUARED,..... 0.581

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	5.284E0	5.284E0	
REGRESSION	47	2.244E1	4.775E-1	2.187
TYPE 1	6	3.224E0	5.373E-1	2.460
TYPE 2	11	5.201E0	4.728E-1	2.165
TYPE 3	2	3.059E-1	1.529E-1	0.700
TYPE 4	28	9.683E0	3.458E-1	1.584
RESIDUALS	74	1.616E1	2.184E-1	
TOTAL	122	4.389E1		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
		INTERCEPT	0.078	0.461	122
1	3125	1	-0.046	0.272	5
2	8	2	-0.418	0.340	5
3	31	3	-0.379	0.271	10
5	59	4	-0.596	0.197	42
1	3124	5	0.049	0.176	29
	11115	6	0.313	0.267	5
	11126	7	0.317	0.254	7
	16127	8	0.519	0.250	9
	20127	9	0.274	0.230	13
	27125	10	0.324	0.232	14
2	1	11	0.199	0.256	10
	2	12	-0.295	0.256	8
	3	13	0.121	0.262	13
	4	14	0.093	0.256	8
	5	15	-0.294	0.265	10
	6	16	-0.356	0.240	11
	7	17	0.127	0.263	7
	9	18	-0.261	0.225	8
	10	19	-0.003	0.124	35
	11	20	-0.065	0.416	7
	12	21	0.237	0.649	1
3	22	22	0.537	0.466	7
	23	23	0.499	0.511	3
5	60	24	0.422	0.493	4
	62	25	0.347	0.445	6
	63	26	0.172	0.435	14
	64	27	-0.063	0.542	2
	65	28	0.188	0.473	3
	66	29	-0.262	0.534	2
	67	30	-0.026	0.557	2
	68	31	0.132	0.717	1
	69	32	-0.328	0.459	5
	70	33	-0.530	0.651	1
	71	34	-0.205	0.503	3
	72	35	0.175	0.460	3
	73	36	-0.184	0.494	3
	74	37	-0.979	0.456	5
	75	38	-0.789	0.439	7
	76	39	-0.467	0.448	5
	77	40	-0.430	0.408	9
	78	41	-0.281	0.422	9
	79	42	-0.285	0.495	3
	80	43	0.026	0.453	4
	81	44	-0.606	0.687	1
	82	45	-0.376	0.468	5
	83	46	-0.020	0.486	3
	84	47	-0.747	0.495	2
	85				
	86				
	87				
	88				

Table 16. ANOVA table and parameter estimates from a multiplicative analysis of catch rate data incorporating a percentage of redfish category type (PCT) and excluding the 1974 data (see text).

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.728
MULTIPLE R SQUARED..... 0.530

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	5.577E1	5.577E1	
REGRESSION	73	1.554E2	2.128E0	10.490
TYPE 1	27	3.259E1	1.207E0	5.949
TYPE 2	11	2.719E1	2.472E0	12.184
TYPE 3	2	1.105E0	5.524E-1	2.723
TYPE 4	4	4.393E1	1.098E1	54.129
TYPE 5	29	2.482E1	8.559E-1	4.219
RESIDUALS	680	1.380E2	2.029E-1	
TOTAL	754	3.491E2		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	3125	INTERCEPT	0.602	0.133	754
2	8				
3	31				
4	95				
5	59				
1	2125	1	0.164	0.121	20
	2154	2	-0.134	0.198	6
	2155	3	0.305	0.148	12
	3124	4	-0.284	0.091	31
	3155	5	0.130	0.104	28
	11115	6	-0.736	0.182	12
	11116	7	-0.379	0.191	9
	11125	8	-0.126	0.142	12
	11126	9	-0.311	0.146	19
	11127	10	-0.176	0.126	18
	12105	11	-0.339	0.170	12
	12106	12	-0.202	0.153	18
	14124	13	0.670	0.180	7
	14125	14	-0.261	0.168	8
	14126	15	0.245	0.108	22
	14127	16	0.031	0.181	7
	16127	17	-0.386	0.091	93
	17116	18	0.255	0.337	2
	17127	19	-0.007	0.186	7
	20114	20	-1.149	0.154	16
	20116	21	-0.723	0.164	17
	20126	22	-0.293	0.237	5
	20127	23	0.022	0.073	91
	20157	24	0.149	0.167	8
	27124	25	-0.159	0.160	9
	27125	26	0.104	0.060	95
	27126	27	0.309	0.210	5

Table 16. (continued)

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
2	1	28	0.447	0.111	21
	2	29	0.575	0.108	24
	3	30	0.408	0.083	47
	4	31	0.416	0.083	54
	5	32	0.178	0.077	60
	6	33	-0.249	0.075	61
	7	34	-0.033	0.072	69
	9	35	0.012	0.066	90
	10	36	-0.132	0.068	86
	11	37	-0.087	0.074	71
	12	38	0.032	0.078	62
3	22	39	0.022	0.102	24
	23	40	0.096	0.042	211
4	55	41	-0.908	0.069	69
	65	42	-0.693	0.066	77
	75	43	-0.403	0.057	105
	85	44	-0.197	0.044	197
5	60	45	0.030	0.167	12
	61	46	-0.017	0.235	5
	62	47	0.198	0.220	6
	63	48	0.463	0.173	20
	64	49	0.444	0.173	19
	65	50	0.209	0.171	19
	66	51	0.296	0.195	11
	67	52	0.276	0.166	34
	68	53	-0.179	0.195	12
	69	54	-0.185	0.221	6
	70	55	-0.024	0.228	5
	71	56	-0.008	0.193	9
	72	57	-0.204	0.208	9
	73	58	-0.333	0.185	10
	75	59	-0.288	0.222	8
	76	60	-0.257	0.154	23
	77	61	-0.176	0.141	34
	78	62	-0.316	0.135	61
	79	63	-0.287	0.137	47
	80	64	-0.239	0.134	34
	81	65	-0.239	0.139	34
	82	66	-0.059	0.138	39
	83	67	0.029	0.149	25
	84	68	0.257	0.137	40
	85	69	0.195	0.137	45
	86	70	-0.220	0.133	60
	87	71	0.047	0.134	46
	88	72	-0.308	0.142	31
	89	73	-0.117	0.183	11

Table 17. Predicted catch rate series from a multiplicative analysis of catch rate data incorporating a percentage of redfish category type (PCT) and excluding the 1974 data (see text).

PREDICTED CATCH RATE

YEAR	LN TRANSFORM MEAN	LN TRANSFORM S.E.	RETRANSFORMED MEAN	RETRANSFORMED S.E.	CATCH	EFFORT
1959	0.6021	0.0176	2.003	0.265	186837	93259
1960	0.6318	0.0284	2.053	0.344	129773	63223
1961	0.5849	0.0567	1.931	0.454	55455	28717
1962	0.8000	0.0452	2.408	0.507	19657	8162
1963	1.0648	0.0223	3.175	0.472	23644	7447
1964	1.0458	0.0230	3.114	0.470	50154	16106
1965	0.8109	0.0222	2.463	0.365	40425	16413
1966	0.8981	0.0307	2.676	0.466	32730	12230
1967	0.8778	0.0208	2.635	0.378	26162	9927
1968	0.4233	0.0303	1.665	0.288	18881	11341
1969	0.4169	0.0445	1.643	0.343	19883	12105
1970	0.5783	0.0496	1.925	0.424	16970	8815
1971	0.5941	0.0319	1.973	0.350	19306	9784
1972	0.3986	0.0348	1.621	0.300	20033	12362
1973	0.2694	0.0257	1.431	0.228	38965	27237
1975	0.3140	0.0408	1.485	0.297	25559	17215
1976	0.3453	0.0152	1.552	0.191	25965	16735
1977	0.4265	0.0114	1.686	0.180	17539	10403
1978	0.2856	0.0085	1.467	0.135	29146	19874
1979	0.3148	0.0086	1.510	0.140	30730	20353
1980	0.3631	0.0107	1.583	0.163	14519	9172
1981	0.3632	0.0096	1.584	0.155	17642	11137
1982	0.5434	0.0087	1.898	0.177	17983	9477
1983	0.6312	0.0120	2.068	0.226	15311	7402
1984	0.8589	0.0087	2.602	0.243	23689	9106
1985	0.7974	0.0078	2.447	0.215	29225	11941
1986	0.3819	0.0068	1.616	0.133	27019	16718
1987	0.6495	0.0078	2.111	0.186	18511	8769
1988	0.2938	0.0100	1.478	0.147	6936	4694
1989	0.4848	0.0213	1.778	0.258	2675	1504

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.142

Table 18. Mean numbers of redfish caught per standard tow in Division 2J during Canadian research surveys, 1978-1989. Numbers in brackets are number of successful sets, "(*)" indicates those strata estimated with the multiplicative model (MA).

Stratum	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
203	16.00(2)	6.00(2)	17.50(2)	6.75(2)	11.33(3)	10.83(3)	16.00(2)	2.00(3)	1.00(2)	0.33(3)	0.00(2)	1.33(3)
204	23.50(2)	16.00(2)	7.00(1)	16.50(2)	1.67(3)	15.67(3)	23.50(2)	0.00(2)	0.50(2)	0.00(2)	0.50(2)	1.50(2)
208	135.50(2)	2059.00(2)	29.50(2)	14.50(2)	18.67(3)	11.50(2)	52.67(3)	32.67(3)	0.50(2)	2.50(2)	1.50(2)	3.50(2)
209	3.50(2)	0.00(2)	5.50(2)	0.50(6)	0.09(11)	0.43(7)	0.14(7)	0.11(9)	0.00(7)	0.38(8)	0.00(5)	0.00(8)
210	66.00(3)	9.00(2)	2.50(2)	0.00(3)	17.72(6)	1.00(2)	22.25(4)	0.50(4)	0.33(3)	0.75(4)	6.00(3)	0.00(4)
211	44.50(2)	40.50(2)	66.00(2)	993.25(2)	46.00(2)	0.50(2)	109.50(3)	154.67(3)	1.50(2)	9.50(2)	2.00(2)	11.00(2)
212	5.50(2)	12.50(2)	2.00(2)	4.00(2)	7.00(5)	7.50(3)	18.00(2)	5.50(4)	6.33(3)	2.00(4)	0.00(2)	0.75(4)
213	236.67(3)	249.33(3)	1.00(3)	10.17(6)	12.06(10)	320.10(10)	150.80(5)	1.89(9)	0.00(9)	1.22(9)	1.13(8)	0.00(9)
214	258.67(3)	7.50(2)	0.00(2)	148.00(5)	74.75(8)	77.88(8)	0.75(4)	1.67(6)	4.83(6)	3.00(6)	6.17(6)	0.50(6)
215	24.00(3)	13.50(2)	27.50(2)	2.80(5)	3.00(9)	5.25(8)	5.33(3)	1.17(6)	5.52(5)	0.43(7)	0.43(7)	0.67(6)
216	4298.00(2)	635.50(2)	1745.50(2)	187.00(2)	479.50(2)	360.00(3)	539.00(2)	197.00(2)	667.41(2)	399.50(2)	123.00(2)	44.00(2)
217	1779.50(2)	423.00(2)	890.50(2)	146.50(2)	468.50(2)	487.00(2)	594.30(*)	152.50(2)	407.50(2)	203.50(2)	560.50(2)	46.50(2)
218	982.00(2)	393.33(*)	520.00(2)	156.50(2)	87.50(2)	168.50(2)	387.91(*)	83.00(2)	64.00(2)	333.00(2)	324.00(2)	110.50(2)
219	27.00(1)	5.99(*)	4.51(*)	14.25(2)	4.28(*)	2.00(2)	5.91(*)	0.00(2)	22.00(2)	0.50(2)	2.50(2)	0.00(2)
222	3286.00(2)	886.00(2)	1120.50(2)	2629.00(2)	1848.00(3)	2460.33(3)	835.00(3)	399.00(2)	111.00(2)	130.50(2)	2383.00(2)	21.00(2)
223	2499.50(2)	530.50(2)	1113.00(2)	877.00(2)	652.00(2)	510.50(2)	573.00(2)	574.00(2)	950.00(2)	149.00(2)	733.00(2)	75.00(2)
224	1176.00(2)	720.00(2)	498.50(2)	342.50(2)	151.00(2)	169.50(2)	220.50(2)	37.50(2)	214.37(2)	205.50(2)	442.00(2)	21.00(2)
227	1319.50(2)	231.50(2)	223.00(2)	20.50(2)	185.20(5)	135.00(4)	116.33(3)	89.75(4)	287.33(3)	60.25(4)	9.00(3)	12.75(4)
228	177.00(3)	11.50(2)	1029.50(2)	4590.00(6)	109.10(10)	226.83(6)	227.29(7)	0.14(7)	47.00(6)	17.71(7)	14.40(5)	5.88(8)
229	175.00(2)	408.00(2)	659.00(2)	1607.00(2)	1262.50(4)	1110.75(4)	293.00(3)	280.33(3)	689.33(3)	19.33(3)	5.67(3)	67.33(3)
230	2106.00(2)	337.27(*)	262.75(2)	126.50(2)	210.00(2)	116.00(2)	125.50(2)	113.00(2)	470.00(2)	221.50(2)	54.50(2)	118.50(2)
231	0.00(2)	8.77(*)	3.00(2)	19.00(1)	4.50(2)	5.00(2)	32.50(2)	23.50(2)	9.50(2)	2.00(2)	8.00(2)	1.00(1)
235	10.00(2)	48.00(2)	41.00(2)	9.00(2)	16.67(3)	28.50(2)	84.67(3)	12.50(2)	4.00(2)	17.00(2)	35.00(2)	3.00(2)
236	18.45(*)	6.34(*)	4.77(*)	8.00(2)	4.50(3)	5.00(2)	8.50(2)	20.00(2)	6.80(2)	3.50(2)	0.00(2)	0.07(*)
Mean												
STRAP	517.94	213.87	295.66	667.03	175.80	226.91	127.61	53.12	99.99	43.63	116.86	13.75
MA	506.64	213.71	282.02	658.98	173.30	226.91	141.85	53.12	99.99	43.63	116.87	13.48
Total (x 10^{-6})												
MA	556.84	234.88	309.97	724.27	190.48	249.40	155.91	58.39	109.90	47.96	128.45	14.81

Table 19. Mean numbers of redfish caught per standard tow in Division 3K during Canadian research surveys, 1978–1989. Numbers in brackets are number of successful sets, "(*)" indicates those strata estimated with the multiplicative model (MA).

Stratum	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
620	43.80(5)	19.33(3)	12.00(3)	7.40(10)	0.33(9)	4.70(10)	0.23(13)	0.64(14)	0.00(9)	0.43(14)	0.33(12)	0.93(15)
621	8.60(5)	3.00(3)	8.00(3)	1.36(11)	1.51(14)	0.33(12)	0.50(14)	1.20(15)	0.50(14)	0.33(12)	0.10(10)	0.06(17)
622	93.00(2)	10.33(3)	18.00(2)	27.00(2)	18.33(3)	20.00(2)	8.00(4)	4.00(4)	6.50(2)	1.00(3)	0.67(3)	8.00(3)
623	51.00(3)	4.00(1)	81.50(2)	7.50(4)	6.00(5)	103.67(6)	13.40(5)	5.33(6)	3.00(4)	1.20(5)	7.00(5)	3.83(6)
624	1171.00(4)	173.00(2)	11.50(2)	18.00(2)	5.25(4)	3.75(4)	15.75(4)	3.00(4)	4.50(2)	2.33(3)	2.33(3)	1.33(3)
625	121.33(3)	53.00(2)	85.50(2)	387.75(4)	13.00(2)	324.33(3)	21.00(5)	70.60(5)	0.67(3)	27.50(4)	2.25(4)	9.50(4)
626	118.33(3)	31.00(2)	39.50(2)	140.40(5)	96.60(5)	7.75(4)	8.00(6)	31.90(5)	3.25(4)	12.20(5)	0.40(5)	351.40(5)
627	4.50(2)	25.67(3)	45.50(2)	7.00(6)	16.00(7)	23.00(6)	12.38(8)	3.71(7)	2.60(5)	2.00(6)	1.00(5)	31.17(6)
628	67.50(2)	53.67(3)	8.50(2)	32.83(6)	5.33(6)	14.50(6)	8.29(7)	1.75(6)	0.00(4)	1.80(5)	1.80(5)	0.75(4)
629	292.00(3)	75.43(*)	87.50(2)	49.00(3)	29.50(2)	2070.33(3)	25.00(4)	20.75(4)	16.00(3)	17.67(3)	10.50(2)	3.33(3)
630	305.50(2)	102.00(2)	46.00(2)	19.00(2)	20.15(*)	119.00(2)	212.00(3)	21.94(4)	38.90(2)	1.67(3)	0.67(3)	2.00(3)
631	10.00(2)	28.00(3)	50.33(3)	19.00(5)	9.00(2)	47.80(5)	431.80(5)	167.14(7)	13.64(4)	8.67(6)	14.50(6)	18.71(7)
632	424.50(4)	43.00(2)	288.00(2)	45.00(2)	15.67(3)	35.33(3)	15.00(1)	12.00(3)	9.50(2)	4.50(2)	10.00(2)	5.00(2)
633	6191.75(4)	82.25(4)	413.00(3)	219.33(8)	1393.00(7)	817.73(12)	155.30(10)	921.50(12)	40.72(8)	24.82(11)	30.88(8)	15.70(10)
634	373.25(4)	28.50(2)	138.50(2)	33.19(7)	112.27(11)	8899.80(5)	48.57(7)	27.56(9)	45.40(5)	12.91(11)	10.50(6)	13.63(7)
635	776.75(4)	275.00(3)	59.50(2)	2927.20(5)	6.00(5)	4.33(6)	43.63(8)	13.00(7)	6.29(6)	4.00(6)	3.20(5)	30.14(7)
636	964.75(4)	118.50(2)	3318.00(2)	41.67(6)	32.50(10)	118.00(6)	16.00(8)	7.88(8)	14.25(4)	5.57(7)	7.00(6)	3.60(5)
637	605.50(5)	759.67(3)	188.00(2)	661.50(6)	41.71(7)	292.60(5)	12.50(6)	62.00(7)	11.05(4)	4.67(6)	8.50(8)	3.80(5)
638	478.00(3)	182.00(2)	857.33(3)	121.25(8)	81.64(10)	151.00(11)	166.80(10)	105.64(11)	19.75(4)	96.50(10)	840.88(8)	33.09(11)
639	798.75(4)	2118.50(2)	392.00(2)	95.83(6)	553.10(15)	6536.43(7)	753.87(8)	733.00(8)	1435.00(6)	177.14(7)	204.67(6)	22.25(8)
640	1497.00(2)	564.78(*)	1190.00(2)	410.50(2)	480.50(2)	687.19(*)	279.50(2)	552.00(3)	202.00(2)	268.00(2)	388.50(2)	51.50(2)
641	693.50(2)	154.00(2)	399.00(2)	199.50(2)	186.25(4)	55.67(3)	100.00(3)	111.25(4)	26.51(*)	52.33(3)	24.11(*)	25.14(*)
642	1.00(2)	2.00(1)	4.50(2)	1.33(3)	3.83(6)	4.74(*)	5.33(6)	11.40(5)	0.18(*)	1.80(5)	0.12(*)	0.15(*)
645	1774.50(2)	1007.14(*)	1280.50(2)	538.00(2)	710.33(3)	1659.50(2)	141.50(2)	1328.67(3)	158.38(*)	423.00(2)	589.00(2)	1948.00(2)
646	2411.00(2)	20.50(2)	115.50(2)	149.50(2)	1185.00(2)	960.00(2)	471.00(2)	272.33(3)	50.24(*)	341.50(2)	45.74(*)	47.67(*)
647	23.00(2)	0.50(2)	34.10(2)	6.50(2)	0.50(2)	2.00(1)	56.00(1)	205.92(3)	0.88(*)	0.80(*)	0.75(*)	0.81(*)
Mean												
STRAP	811.34	219.98	349.69	227.04	187.22	1072.82	108.22	154.96	94.28	32.19	90.79	38.97
MA	811.10	210.52	349.62	226.99	183.99	1019.32	105.99	154.93	88.39	31.74	84.62	36.97
Total (x 10^{-6})												
MA	1733.38	449.90	747.17	485.08	393.20	2178.36	226.50	331.09	188.90	67.82	180.83	79.01

Table 20. Mean weight of redfish caught per standard tow in Division 2J during Canadian research surveys, 1978-1989. Numbers in brackets are number of successful sets, "(*)" indicates those strata estimated with the multiplicative model (MA).

Stratum	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
203	1.34(2)	0.68(2)	3.25(2)	0.75(2)	2.40(3)	1.48(3)	3.75(2)	0.08(3)	0.30(2)	0.03(3)	0.00(2)	0.54(3)
204	5.66(2)	7.03(2)	1.00(1)	3.40(2)	0.43(3)	2.63(3)	5.00(2)	0.00(2)	0.15(2)	0.00(2)	0.25(2)	0.59(2)
208	42.39(2)	1540.40(2)	17.75(2)	26.00(2)	7.17(3)	2.85(2)	20.00(3)	11.50(3)	0.15(2)	0.55(2)	1.20(2)	1.65(2)
209	0.06(2)	0.00(2)	3.70(2)	0.50(6)	0.00(11)	0.13(7)	0.09(7)	0.11(9)	0.00(7)	0.03(8)	0.00(5)	0.00(8)
210	1.51(3)	3.17(2)	1.00(2)	0.00(3)	2.91(6)	0.75(2)	2.00(4)	0.02(4)	0.07(3)	0.22(4)	0.50(3)	0.00(4)
211	18.82(2)	19.29(2)	46.00(2)	987.00(2)	13.75(2)	0.10(2)	38.25(3)	64.75(3)	0.88(2)	3.50(2)	1.10(2)	2.41(2)
212	3.40(2)	4.77(2)	0.55(2)	2.80(2)	3.40(5)	2.65(3)	9.00(2)	1.64(4)	2.63(3)	0.84(4)	0.00(2)	0.21(4)
213	55.04(3)	85.88(3)	0.43(3)	2.79(6)	4.60(10)	92.82(10)	42.30(5)	0.96(9)	0.00(9)	0.45(9)	0.41(8)	0.00(9)
214	75.15(3)	4.54(2)	0.00(2)	54.14(5)	28.19(8)	32.02(8)	0.38(4)	0.67(6)	1.62(6)	1.55(6)	2.70(6)	0.16(6)
215	9.61(3)	6.01(2)	7.50(2)	1.20(5)	0.41(9)	1.66(8)	2.27(3)	0.17(6)	1.40(5)	0.31(7)	0.10(7)	0.11(6)
216	2209.48(2)	267.74(2)	590.17(2)	69.50(2)	195.75(2)	133.67(3)	272.50(2)	70.55(2)	227.14(2)	141.50(2)	50.00(2)	8.43(2)
217	704.90(2)	164.29(2)	470.57(2)	73.75(2)	214.00(2)	239.83(2)	253.50(*)	73.50(2)	181.63(2)	92.50(2)	272.75(2)	20.17(2)
218	611.68(2)	240.97(*)	314.50(2)	92.00(2)	55.50(2)	99.25(2)	214.32(*)	41.25(2)	44.25(2)	194.00(2)	245.75(2)	53.95(2)
219	16.33(1)	4.60(*)	3.77(*)	8.00(2)	2.71(*)	1.90(2)	4.04(*)	0.00(2)	14.70(2)	0.20(2)	1.50(2)	0.00(2)
222	1331.48(2)	302.99(2)	402.50(2)	1033.75(2)	582.00(3)	963.48(3)	303.30(3)	152.50(2)	47.10(2)	63.00(2)	1064.29(2)	6.18(2)
223	1131.28(2)	221.87(2)	538.50(2)	459.16(2)	358.16(2)	271.00(2)	247.00(2)	328.75(2)	606.75(2)	76.25(2)	449.25(2)	28.70(2)
224	836.89(2)	425.01(2)	293.25(2)	204.75(2)	99.00(2)	110.75(2)	114.50(2)	26.25(2)	151.35(2)	138.00(2)	326.25(2)	9.83(2)
227	714.01(2)	148.46(2)	159.25(2)	8.00(2)	99.90(5)	70.88(4)	57.33(3)	45.50(4)	199.22(3)	38.88(4)	4.97(3)	5.18(4)
228	27.97(3)	3.34(2)	437.45(2)	1548.50(6)	31.60(10)	103.54(6)	88.44(7)	0.01(7)	17.93(6)	6.60(7)	5.80(5)	1.57(8)
229	69.61(2)	181.37(2)	285.30(2)	769.25(2)	432.87(4)	364.08(4)	131.83(3)	50.17(3)	321.50(3)	6.67(3)	2.13(3)	26.08(3)
230	1160.53(2)	231.91(*)	196.52(2)	79.75(2)	134.15(2)	74.50(2)	63.25(2)	72.00(2)	326.50(2)	151.00(2)	50.25(2)	80.28(2)
231	0.00(2)	6.30(*)	3.00(2)	11.00(1)	3.50(2)	2.25(2)	17.75(2)	9.75(2)	6.15(2)	1.55(2)	5.30(2)	0.83(1)
235	2.95(2)	17.02(2)	23.50(2)	4.25(2)	6.17(3)	13.25(2)	38.00(3)	5.00(2)	1.00(2)	8.50(2)	15.32(2)	1.37(2)
236	7.31(*)	4.52(*)	3.71(*)	3.75(2)	2.75(3)	3.00(2)	4.75(2)	12.50(2)	6.30(2)	2.35(2)	0.00(2)	0.00(*)
Mean STRAT	236.46	112.69	131.38	260.44	66.06	88.34	50.80	21.19	51.82	22.16	59.54	5.89
MA	231.35	114.51	125.31	257.34	65.14	88.34	58.52	21.19	51.82	22.16	59.54	5.78
Total (MT) MA	254275	125852	137726	282841	71592	97088	64317	23290	56954	24351	65435	6354

Table 21. Mean weight of redfish caught per standard tow in Division 3K during Canadian research surveys, 1978-1989. Numbers in brackets are number of successful sets, "(*)" indicates those strata estimated with the multiplicative model (MA).

Stratum	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
620	13.68(5)	2.34(3)	2.17(3)	1.83(10)	0.05(9)	2.00(10)	0.07(13)	0.09(14)	0.00(9)	0.10(14)	0.01(12)	0.09(15)
621	0.83(5)	0.68(3)	2.90(3)	0.57(11)	0.15(14)	0.00(12)	0.07(14)	0.11(15)	0.04(14)	0.02(12)	0.02(10)	0.00(17)
622	7.26(2)	3.33(3)	5.75(2)	16.25(2)	14.17(3)	14.00(2)	5.50(4)	1.04(4)	1.75(2)	0.40(3)	0.07(3)	1.02(3)
623	6.50(3)	13.60(1)	32.25(2)	2.46(4)	2.80(5)	84.17(6)	5.40(5)	2.67(6)	0.55(4)	0.22(5)	0.76(5)	0.37(6)
624	82.17(4)	13.61(2)	5.00(2)	1.75(2)	1.47(4)	0.63(4)	5.05(4)	0.69(4)	0.85(2)	0.13(3)	0.17(3)	0.03(3)
625	35.90(3)	16.33(2)	54.25(2)	303.50(4)	4.00(2)	219.00(3)	8.30(5)	23.12(5)	0.20(3)	11.27(4)	0.25(4)	1.08(4)
626	51.86(3)	13.15(2)	27.50(2)	77.28(5)	19.36(5)	2.75(4)	2.60(6)	14.73(5)	0.40(4)	2.58(5)	0.06(5)	196.36(5)
627	2.72(2)	7.87(3)	10.75(2)	2.96(6)	4.21(7)	10.57(6)	4.66(8)	0.74(7)	0.54(5)	0.48(6)	0.22(5)	11.74(6)
628	47.17(2)	54.46(3)	9.75(2)	16.82(6)	3.13(6)	11.41(6)	7.67(7)	1.34(6)	0.00(4)	0.50(5)	0.27(5)	0.18(4)
629	234.51(3)	33.24(*)	65.00(2)	28.33(3)	12.50(2)	974.00(3)	7.69(4)	7.42(4)	3.60(3)	9.35(3)	4.50(2)	1.33(3)
630	212.17(2)	56.69(2)	20.50(2)	6.25(2)	9.95(*)	36.75(2)	114.03(3)	14.87(4)	13.90(2)	1.27(3)	0.03(3)	0.54(3)
631	6.14(2)	9.31(3)	16.90(3)	5.80(5)	2.50(2)	23.00(5)	140.12(5)	73.09(7)	4.32(4)	3.08(6)	3.58(6)	5.67(7)
632	59.02(4)	6.47(2)	90.75(2)	9.00(2)	4.17(3)	9.83(3)	5.00(1)	2.87(3)	2.00(2)	0.60(2)	3.05(2)	0.60(2)
633	1496.14(4)	35.16(4)	137.00(3)	56.64(8)	508.52(7)	295.39(12)	62.45(10)	364.25(12)	15.05(8)	7.85(11)	8.95(8)	4.21(10)
634	84.91(4)	7.25(2)	33.50(2)	7.07(7)	42.54(11)	2293.60(5)	18.61(7)	9.74(9)	17.44(5)	4.01(11)	3.45(6)	4.00(7)
635	88.22(4)	159.42(3)	12.50(2)	1192.00(5)	2.46(5)	2.30(6)	18.52(8)	4.57(7)	0.77(6)	1.35(6)	0.26(5)	19.51(7)
636	239.67(4)	24.04(2)	2362.43(2)	11.00(6)	19.05(10)	72.50(6)	4.92(8)	3.91(8)	3.35(4)	1.43(7)	1.66(6)	0.68(5)
637	82.55(5)	232.38(3)	29.50(2)	336.37(6)	18.21(7)	139.22(5)	5.02(6)	25.94(7)	3.25(4)	0.77(6)	2.42(8)	0.88(5)
638	115.88(3)	102.60(2)	260.10(3)	44.31(8)	33.06(10)	65.57(11)	72.85(10)	47.00(11)	7.40(4)	58.70(10)	553.31(8)	15.43(11)
639	352.23(4)	863.46(2)	280.00(2)	28.05(6)	177.42(15)	1903.69(7)	329.92(8)	232.81(8)	786.50(6)	75.56(7)	57.70(6)	11.94(8)
640	488.50(2)	192.56(*)	476.25(2)	181.50(2)	191.50(2)	291.51(*)	96.00(2)	257.41(3)	57.00(2)	96.25(2)	131.00(2)	14.28(2)
641	370.58(2)	84.61(2)	228.00(2)	98.00(2)	88.38(4)	34.50(3)	54.00(3)	47.63(4)	14.74(*)	30.17(3)	12.92(*)	13.36(*)
642	8.57(2)	1.82(1)	3.00(2)	0.67(3)	1.67(6)	3.42(*)	2.79(6)	4.20(5)	0.00(*)	1.00(5)	0.00(*)	0.00(*)
645	746.60(2)	357.84(*)	503.70(2)	204.25(2)	249.00(3)	623.50(2)	51.25(2)	468.74(3)	62.69(*)	210.75(2)	210.50(2)	619.98(2)
646	1398.40(2)	13.16(2)	77.00(2)	103.25(2)	684.00(2)	512.00(2)	313.00(2)	153.17(3)	33.31(*)	255.50(2)	29.27(*)	30.23(*)
647	18.60(2)	0.27(2)	12.35(2)	2.50(2)	0.25(2)	0.80(1)	28.50(1)	145.33(3)	0.36(*)	0.33(*)	0.25(*)	0.28(*)
Mean STRAP	220.37	89.04	189.77	96.73	70.91	323.53	46.13	60.33	48.71	15.99	50.86	16.25
MA	220.26	85.12	189.73	96.70	69.73	308.00	45.22	60.32	45.64	15.76	47.43	15.59
Total (MT) MA	470721	181898	405461	206661	149018	658227	96637	128909	97533	33684	101358	33322

Table 22. Mean numbers of redfish caught per standard tow in Divisions 2GH during Canadian research surveys 1979-1988. Numbers in brackets are number of successful sets; * indicates strata not fished.

Stratum	1979	1981	1986	1987	1988
901	0.57(7)	0.00(6)	*	0.25(4)	0.00(5)
902	*	*	*	6.00(3)	16.50(2)
903	185.00(2)	72.25(2)	*	22.00(2)	31.00(2)
904	283.67(3)	52.00(4)	*	72.83(3)	78.92(3)
905	*	*	*	*	1.00(2)
906	*	*	*	0.90(2)	1.00(2)
908	112.33(3)	5.58(3)	*	4.20(5)	1.50(4)
909	1.08(12)	0.00(8)	*	*	*
910	0.00(8)	0.00(8)	*	*	*
911	27.50(4)	1.00(3)	*	0.00(3)	0.00(2)
912	*	*	*	10.00(2)	1.50(2)
913	*	*	*	12.50(2)	108.50(2)
914	*	*	*	67.50(2)	63.75(2)
915	*	*	*	*	12.00(2)
916	*	*	*	*	0.00(2)
919	*	*	*	*	1.00(2)
920	*	*	*	2.42(4)	9.50(2)
921	432.00(2)	*	*	16.00(2)	12.00(2)
922	*	29.00(2)	*	*	*
923	*	99.00(2)	*	8.50(2)	7.00(2)
924	21.67(3)	7.00(2)	*	0.00(2)	3.20(5)
925	0.00(4)	0.00(3)	*	*	*
926	*	*	*	*	0.00(3)
927	*	*	*	2.20(5)	7.50(4)
928	*	*	*	4.00(3)	0.33(3)
929	41.50(4)	15.67(3)	*	16.00(5)	7.50(4)
930	0.17(6)	0.00(8)	0.20(5)	0.00(9)	0.00(10)
931	7.67(3)	0.33(3)	2.00(2)	0.00(4)	6.67(3)
932	*	*	*	11.00(2)	3.50(7)
933	*	*	*	*	37.00(2)
934	670.73(2)	*	225.50(2)	140.00(2)	13.33(3)
935	*	*	*	0.00(2)	0.00(2)
936	*	*	*	5.54(2)	1.50(2)
939	*	*	*	4.15(2)	1.00(2)
940	*	*	*	9.15(2)	0.50(2)
941	*	*	129.00(2)	50.50(2)	10.45(2)
942	34.00(2)	156.50(2)	227.00(3)	59.33(3)	45.00(2)
943	0.00(2)	2.00(2)	0.00(2)	0.00(4)	9.00(4)
944	66.56(9)	40.89(9)	18.14(2)	6.01(10)	16.13(8)
945	53.67(3)	4.00(6)	*	5.00(5)	7.00(5)
946	10.40(5)	0.14(7)	*	4.70(8)	4.33(6)
947	1.00(2)	0.25(4)	*	2.00(3)	2.50(2)
951	73.50(2)	5.80(3)	*	11.00(2)	5.50(2)
952	55.50(2)	22.00(2)	*	9.00(3)	39.33(3)
953	61.33(3)	14.25(4)	*	1.33(3)	67.00(3)

Table 22 (Cont'd.)

Stratum	1979	1981	1986	1987	1988
954	0.00(5)	0.00(6)	*	0.00(11)	0.70(10)
955	86.33(3)	167.33(3)	*	11.00(4)	18.50(4)
956	0.00(6)	0.00(4)	*	0.00(10)	0.00(10)
957	0.00(6)	0.00(6)	*	0.00(11)	0.00(14)
958	9.00(2)	0.00(2)	*	0.00(3)	27.67(3)
959	553.67(3)	67.33(3)	*	4.67(3)	45.00(2)
960	277.00(2)	59.50(2)	*	130.67(3)	34.33(3)
961	216.33(3)	39.00(3)	*	37.00(2)	76.00(3)
962	*	*	*	0.92(3)	2.00(2)
963	*	*	*	0.00(2)	1.50(2)
Mean	32.08	10.06	21.14	6.69	8.47
TOTAL ($\times 10^{-6}$)	50.88	16.08	4.35	8.95	12.11

Table 23. Mean weights of redfish caught per standard tow in Divisions 2GH during Canadian research surveys 1979-1988. Numbers in brackets are number of successful sets; * indicates strata not fished.

Stratum	1979	1981	1986	1987	1988
901	0.02(7)	0.00(6)	*	0.00(4)	0.00(5)
902	*	*	*	1.83(3)	2.50(2)
903	62.65(2)	24.25(2)	*	5.38(2)	5.80(2)
904	127.12(3)	30.25(4)	*	23.13(3)	37.13(3)
905	*	*	*	*	0.15(2)
906	*	*	*	0.03(2)	0.20(2)
908	7.57(3)	0.85(3)	*	0.10(5)	0.15(4)
909	0.06(12)	0.00(8)	*	*	*
910	0.00(8)	0.00(8)	*	*	*
911	2.95(4)	0.07(3)	*	0.00(3)	0.00(2)
912	*	*	*	1.90(2)	0.30(2)
913	*	*	*	3.60(2)	22.95(2)
914	*	*	*	27.00(2)	26.50(2)
915	*	*	*	*	5.63(2)
916	*	*	*	*	0.00(2)
919	*	*	*	*	0.45(2)
920	*	*	*	0.97(4)	5.00(2)
921	151.40(2)	*	*	8.10(2)	7.35(2)
922	*	12.75(2)	*	*	*
923	*	40.25(2)	*	1.67(2)	1.15(2)
924	5.30(3)	1.00(2)	*	0.00(2)	0.08(4)
925	0.00(4)	0.00(3)	*	*	*
926	*	*	*	*	0.00(3)
927	*	*	*	0.22(5)	0.78(4)
928	*	*	*	1.13(3)	0.07(3)
929	8.28(4)	5.17(3)	*	4.34(5)	3.58(4)
930	0.15(6)	0.00(8)	0.16(5)	0.00(9)	0.00(10)
931	4.69(3)	0.17(3)	0.65(2)	0.00(4)	1.57(3)
932	*	*	*	3.75(2)	2.30(2)
933	*	*	*	*	17.90(2)
934	129.53(2)	*	125.25(2)	70.00(2)	8.37(3)
935	*	*	*	0.00(2)	0.00(2)
936	*	*	*	4.15(2)	0.50(2)
939	*	*	*	1.52(2)	0.60(2)
940	*	*	*	3.38(2)	0.20(2)
941	*	*	56.25(2)	40.75(2)	8.88(2)
942	16.11(2)	77.50(2)	102.00(3)	17.90(3)	22.30(2)
943	0.00(2)	1.00(2)	0.00(2)	0.00(4)	0.60(4)
944	14.62(9)	21.11(9)	3.46(2)	1.16(10)	1.33(8)
945	8.32(3)	1.42(6)	*	1.09(5)	1.02(5)
946	2.23(5)	0.04(7)	*	1.07(8)	0.21(6)
947	0.14(2)	0.03(4)	*	0.40(3)	0.45(2)
951	12.94(2)	1.28(3)	*	3.00(2)	0.90(2)
952	5.33(2)	2.25(2)	*	1.77(3)	2.97(3)
953	0.91(3)	0.45(4)	*	0.00(3)	0.90(3)

Table 23 (Cont'd.)

Stratum	1979	1981	1986	1987	1988
954	0.00(5)	0.00(6)	*	0.00(11)	0.11(10)
955	10.29(3)	62.00(3)	*	0.31(4)	0.88(4)
956	0.00(6)	0.00(4)	*	0.00(10)	0.00(10)
957	0.00(6)	0.00(6)	*	0.00(11)	0.00(14)
958	3.18(2)	0.00(2)	*	0.00(3)	1.80(3)
959	278.75(3)	31.17(3)	*	0.47(3)	7.25(2)
960	113.50(2)	24.00(2)	*	34.67(3)	7.70(3)
961	106.39(3)	21.67(3)	*	14.00(2)	35.33(3)
962	*	*	*	0.28(3)	0.85(2)
963	*	*	*	0.00(2)	0.55(2)
Mean	9.03	4.01	8.65	2.09	1.96
Total (MT)	14331	6409	1780	2798	2799

TABLE 24. Biomass from Div. 2J3K fall surveys estimated by STRAP and the ACON contouring algorithms.

SURVEY (Month_year)	VOLUME (from ACON)	BIOMASS (t) ACON*	STRAP
AS_78	3.8755×10^7	847,586	715,518
N_78	1.6925×10^7	370,166	172,470
O_79	2.7218×10^7	593,299	285,220
ND_79	5.9603×10^6	130,345	144,664
O_80	4.2785×10^7	935,723	543,078
ND_80	7.0665×10^5	15,455	55,394
ND_81	2.4880×10^7	544,134	489,363
ND_82	6.0736×10^6	132,832	220,168
ND_83	2.1312×10^7	466,101	751,004
ND_84	5.7858×10^6	126,537	148,015
ON_85	6.8639×10^6	150,116	152,201
ND_86	6.3406×10^6	138,671	152,038
ND_87	2.1066×10^6	46,072	58,028
ND_88	3.0760×10^6	67,273	165,489
ND_89	1.0469×10^6	22,896	45,097

* calculated as:

$$\frac{\text{VOL (based on sq. Km)}}{\text{area of a 30 MIN tow}} = \frac{\text{VOL}}{.045724}$$

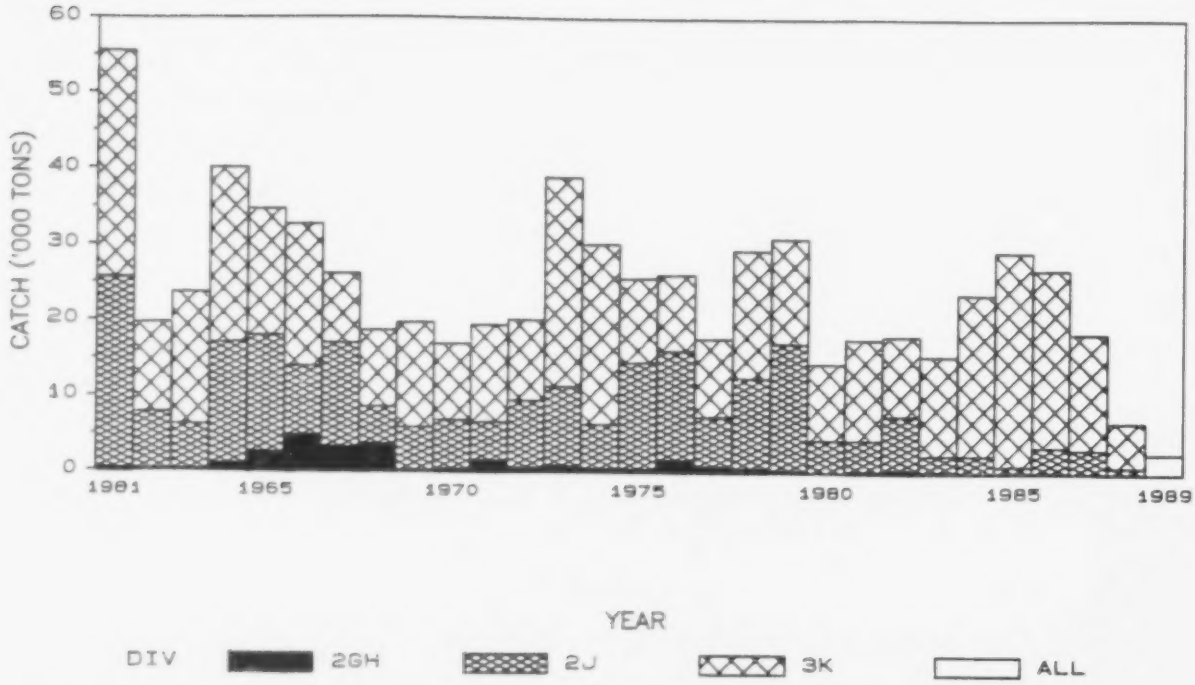


Fig. 1. Nominal catches for redfish in NAFO Subarea 2 and Div. 3K (1988–89 are provisional).

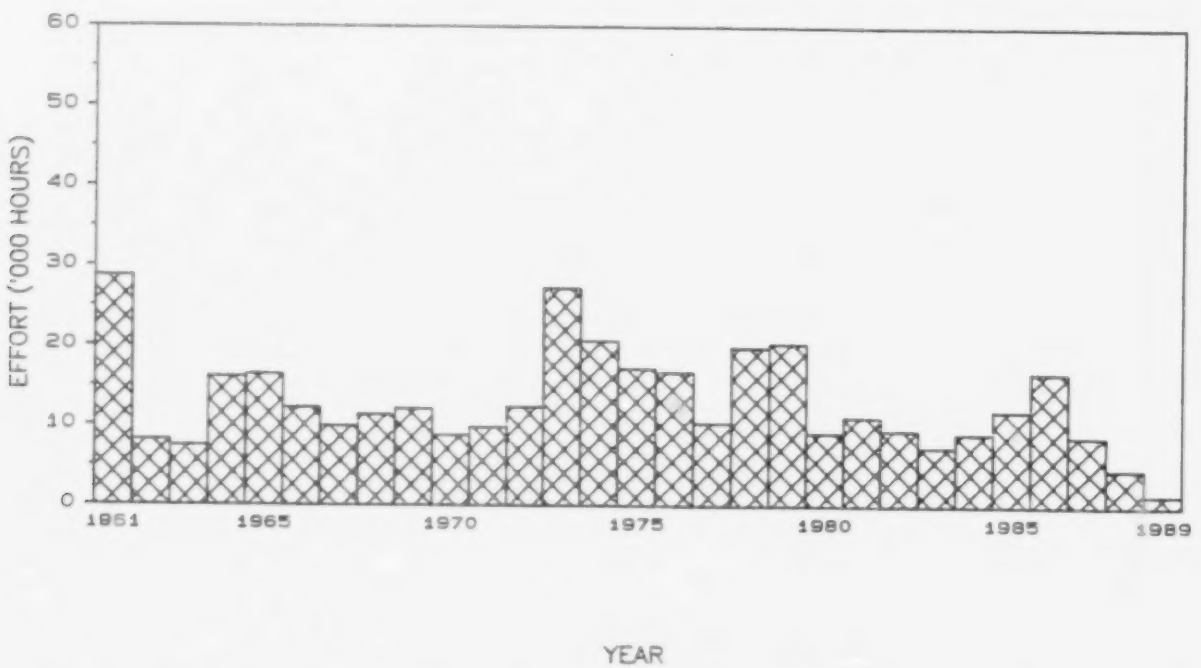


Fig. 2. Standardized effort ('000 hours) for redfish in NAFO Subarea 2 and Div. 3K derived from a multiplicative model of CPUE data (1988–89 used provisional data).

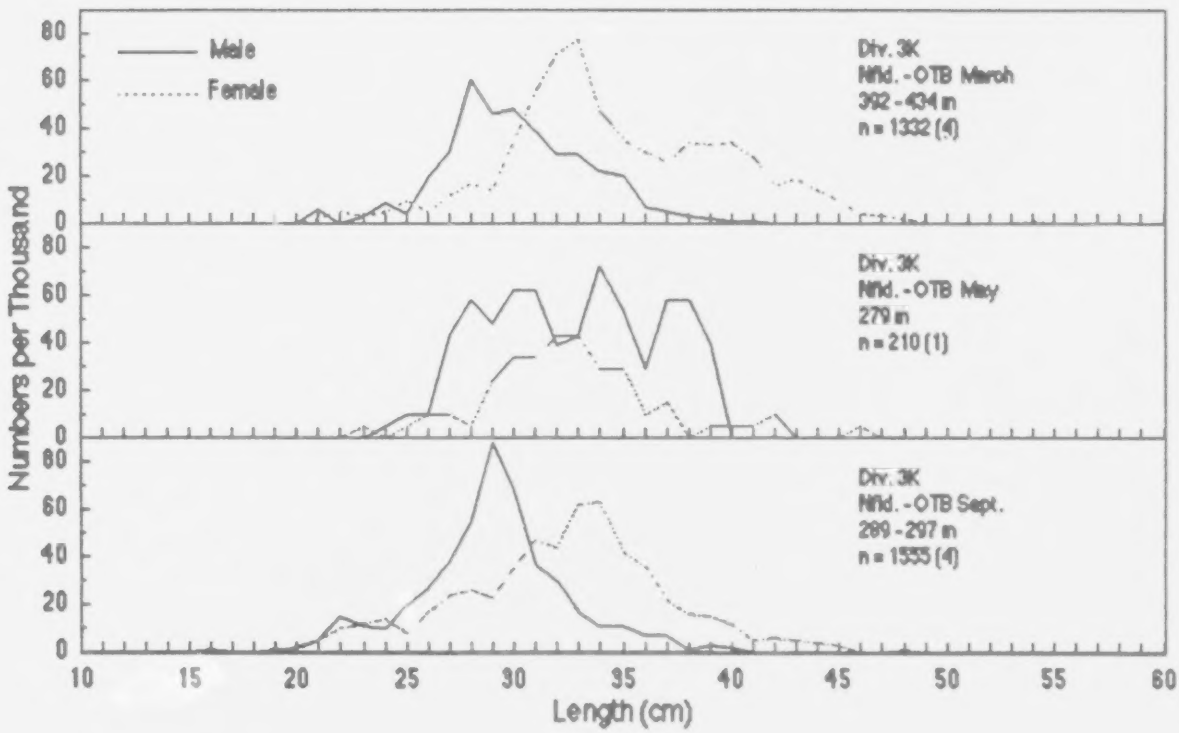


Figure 3. Length frequencies from port sampling of the commercial redfish fishery by Canada (Nfld.) in NAFO Div. 3K in 1989.

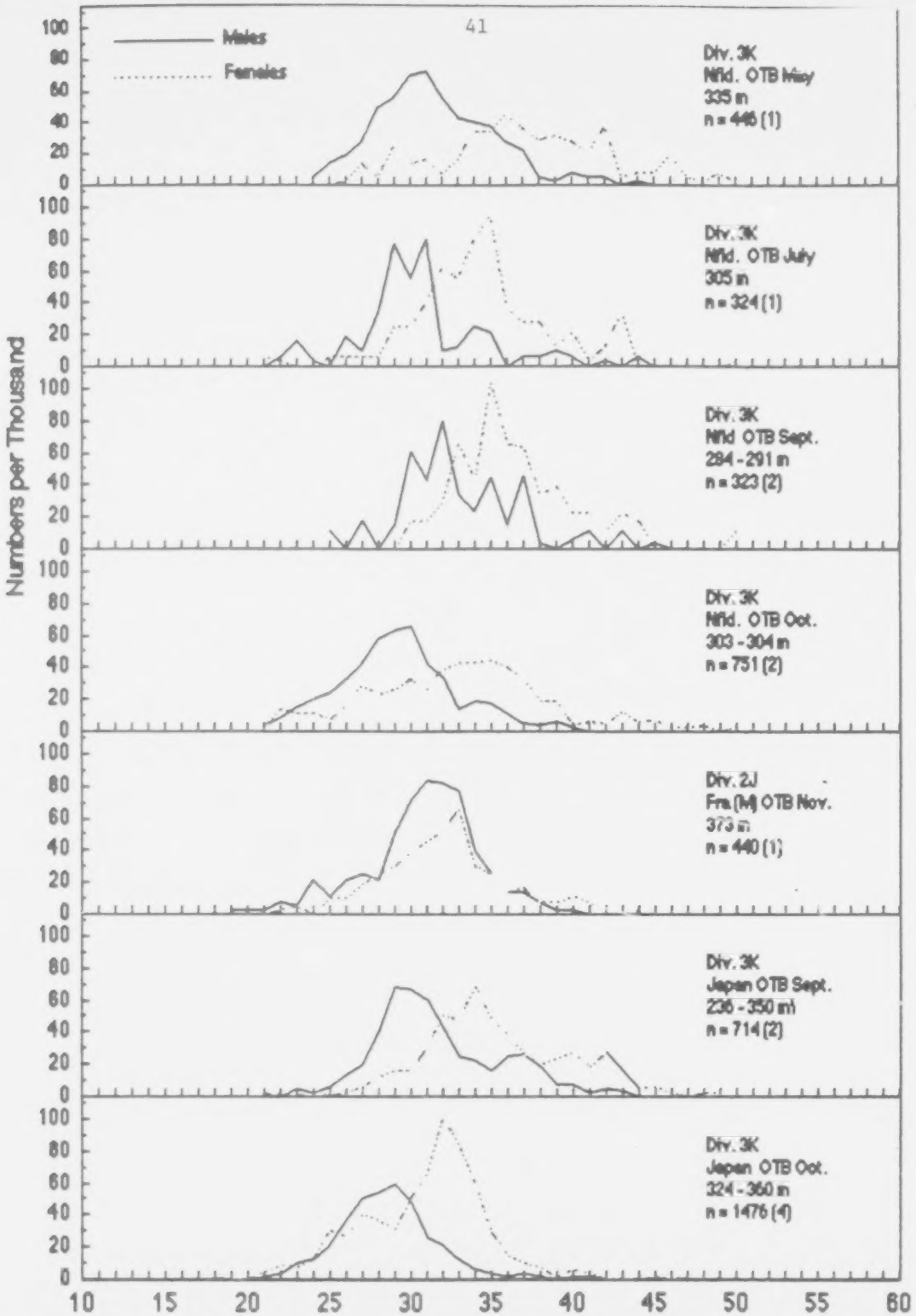


Figure 4. Length frequencies from the commercial redfish fishery in NAFO Div. 2J and Div. 3K from sampling at sea in 1989.

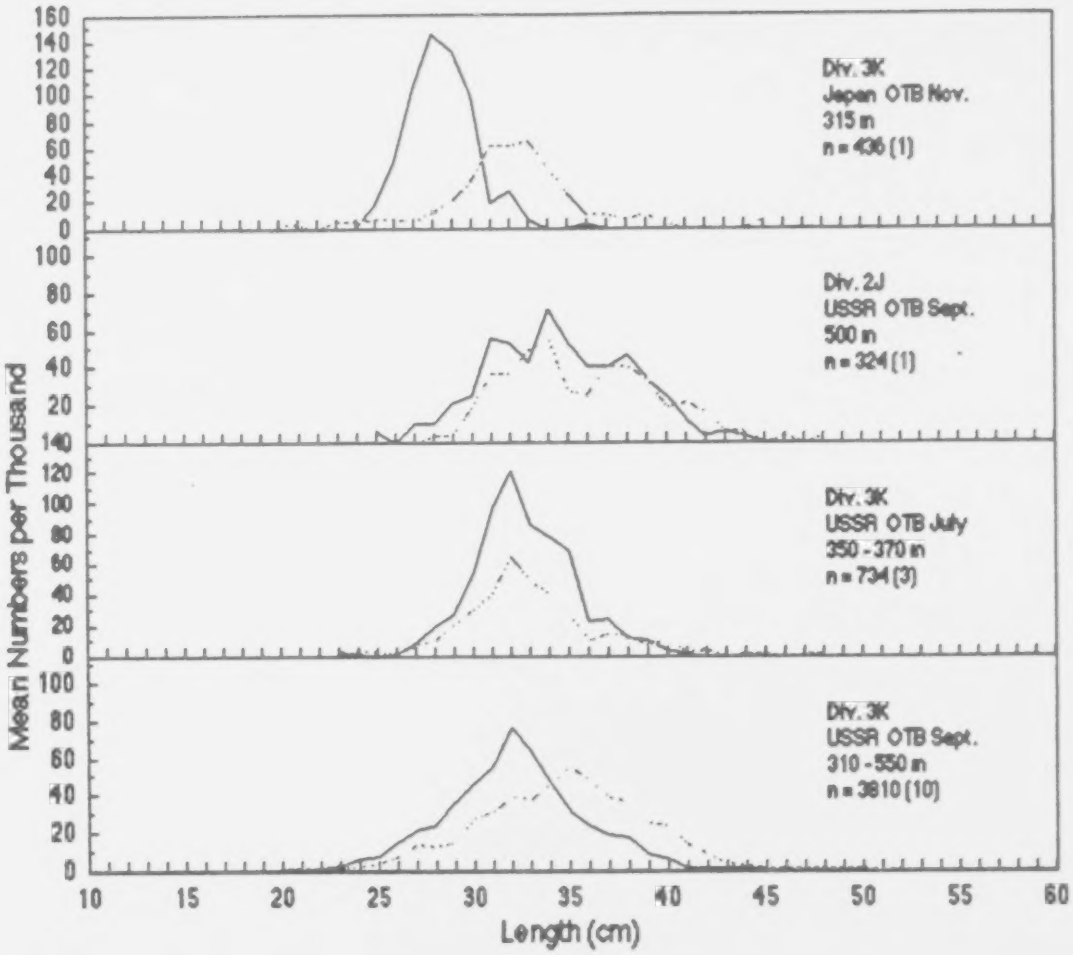
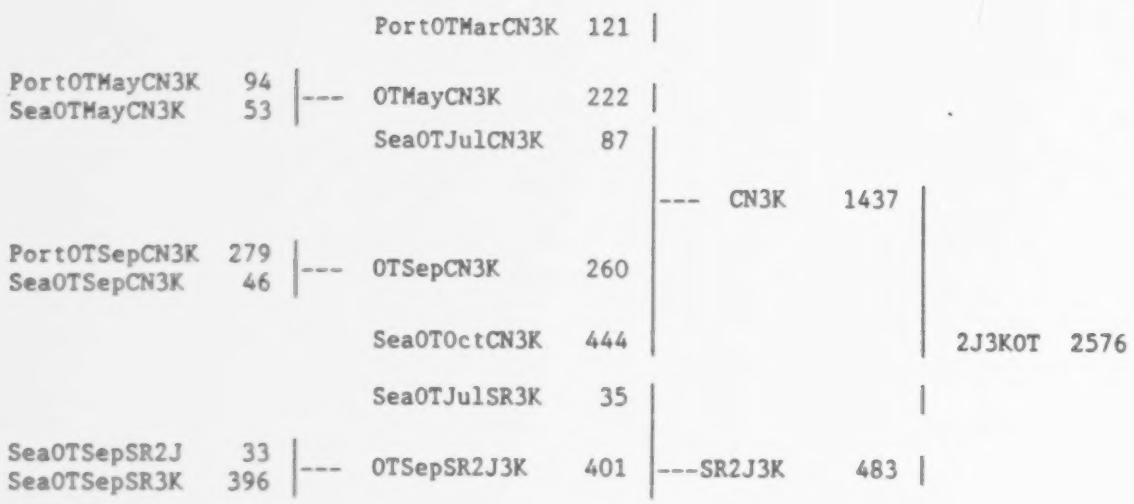


Figure 4. (continued)



Legend: OT = bottom otter trawl
CN = Newfoundland
SR = USSR
Port = port sampled
Sea = observer sampled

Figure 5. Commercial frequencies used and the process of combining these with appropriate weightings to derive the estimated numbers of redfish caught at age in NAFO Subarea 2 and Div. 3K in 1989.

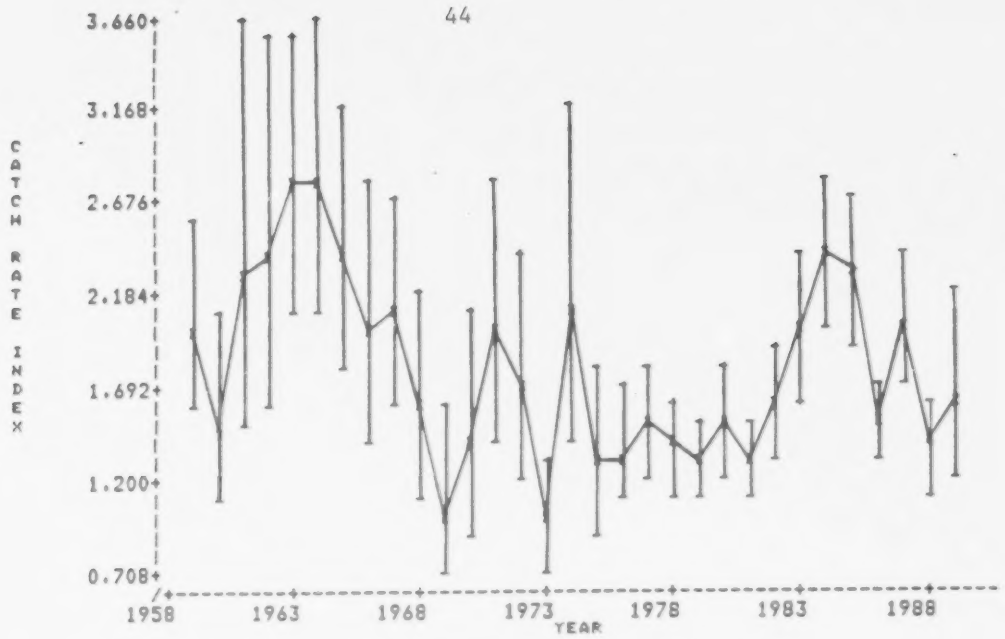


Figure 6. Standardized catch rate series from a multiplicative analysis of catch rate data with no percentage category included (RUN 1, see text).

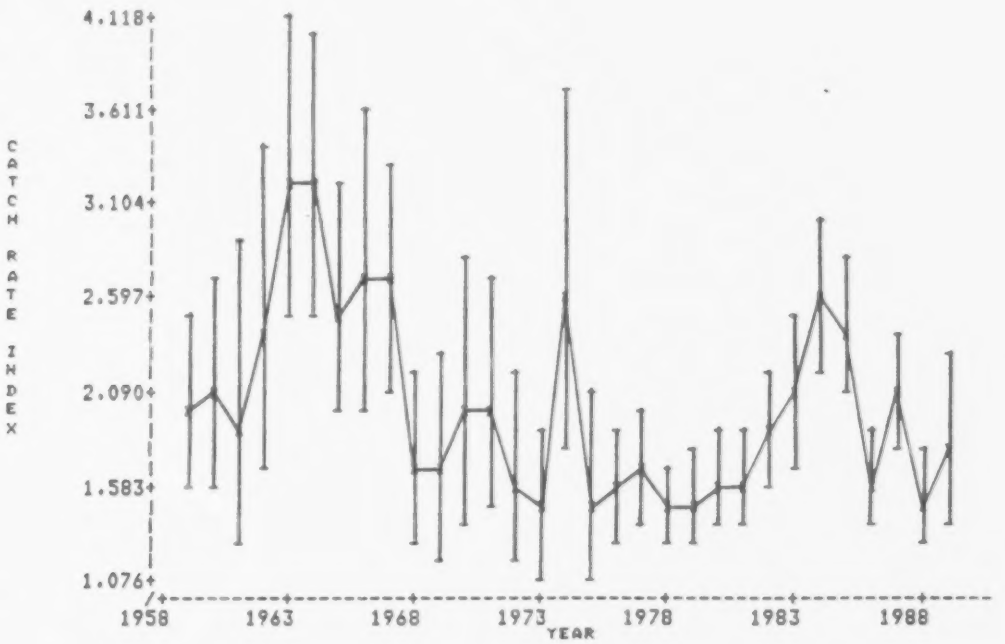


Figure 7. Standardized catch rate series from a multiplicative analysis of catch rate data including a percentage category (RUN 2, see text).

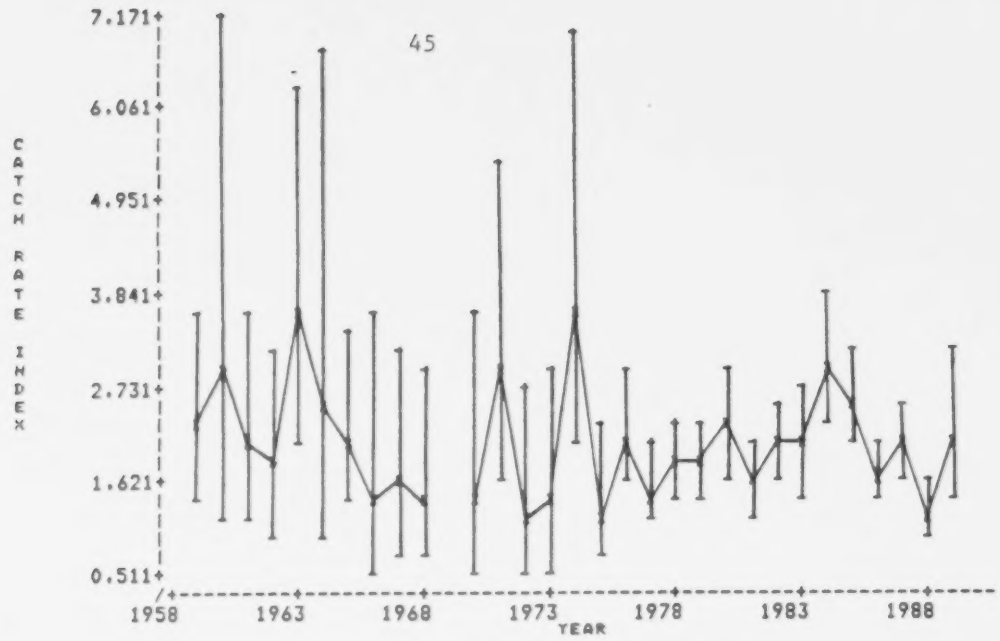


Figure 8. Standardized catch rate series from a multiplicative analysis of catch rate data, RUN 3 (only 95% category included, see text).

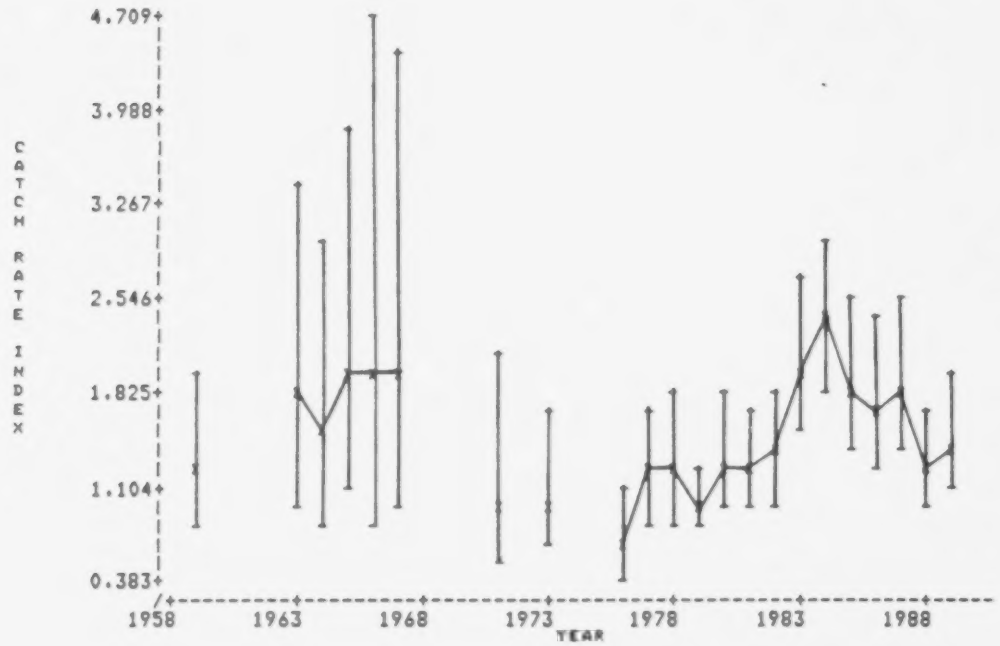


Figure 9. Standardized catch rate series from a multiplicative analysis of catch rate data, RUN 4 (only 85% category included, see text).

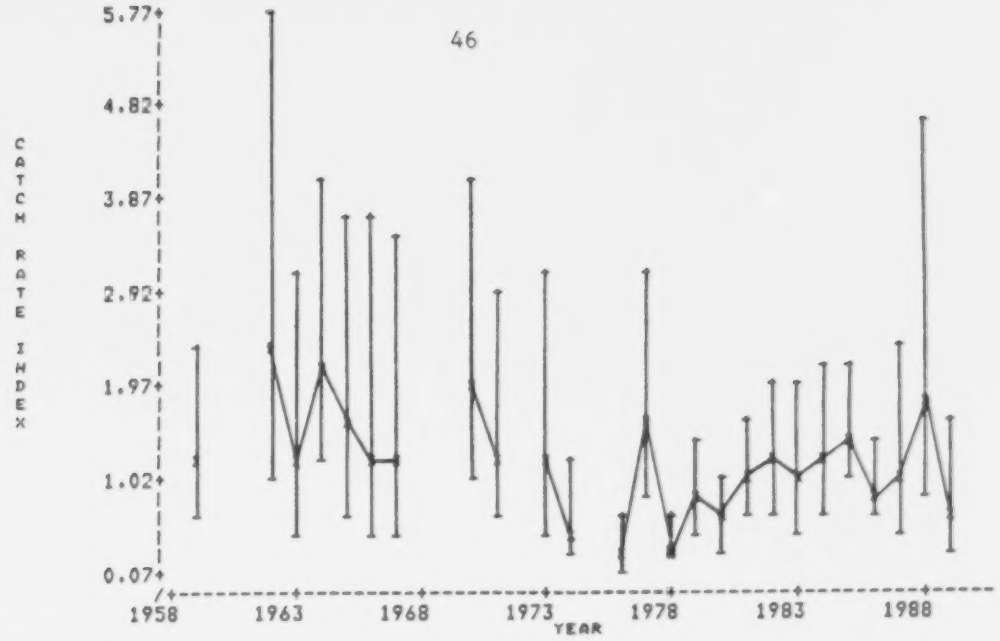


Figure 10. Standardized catch rate series from a multiplicative analysis of catch rate data, RUN 5 (only 75% category included, see text).

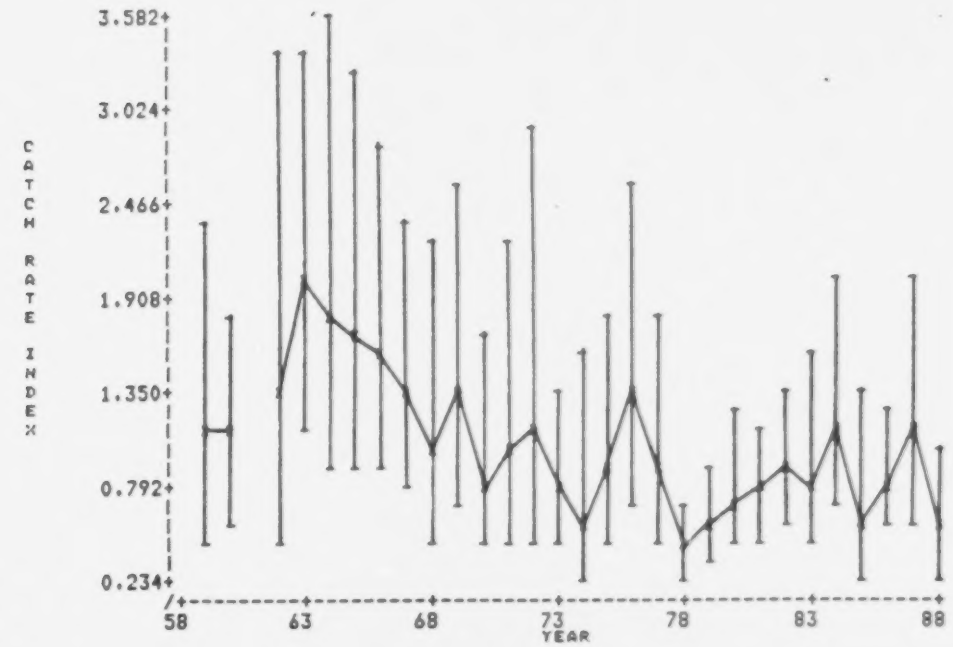


Figure 11. Standardized catch rate series from a multiplicative analysis of catch rate data, RUN 6 (only pooled categories 55% and 65% included, see text).

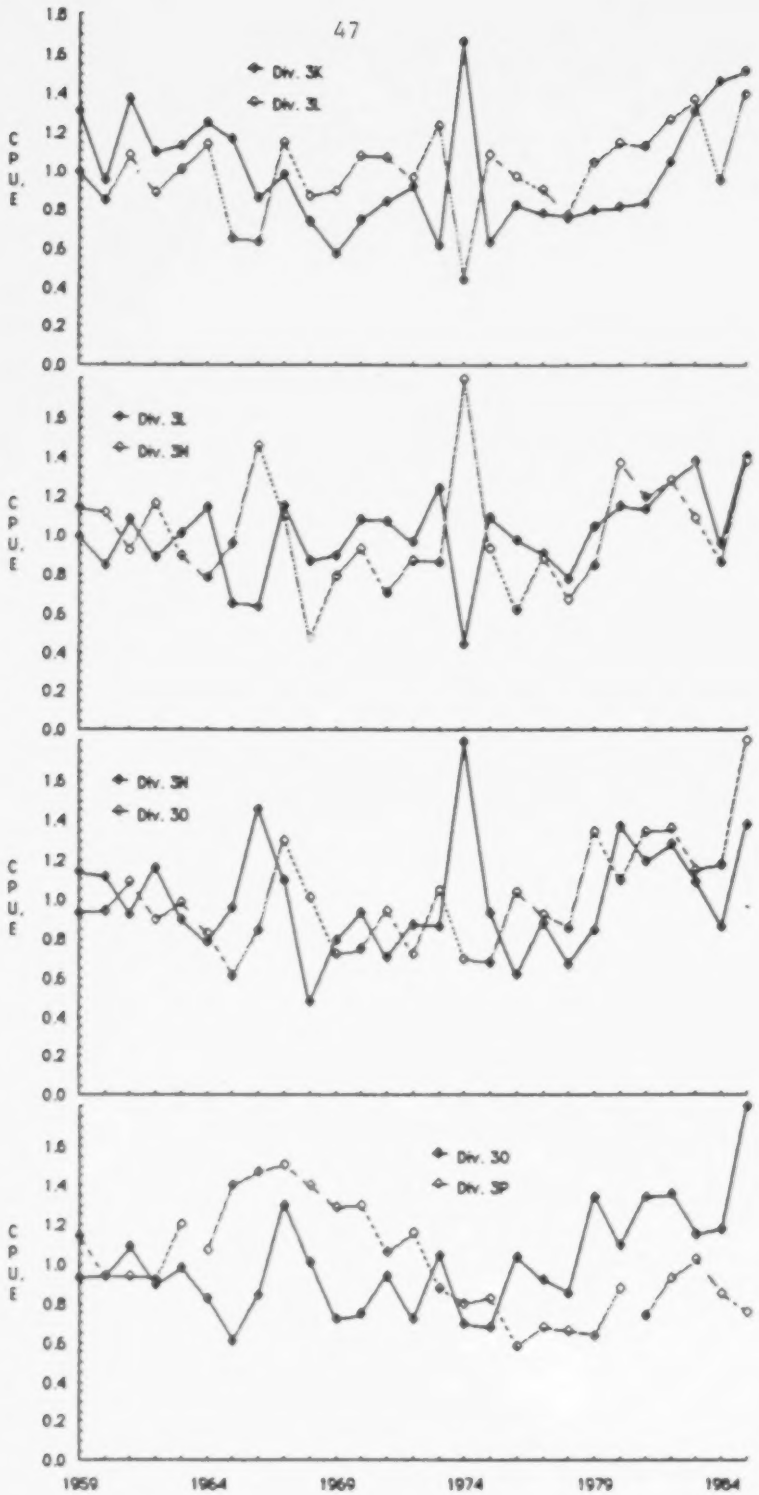


Figure 12. Catch rates for redfish by Division as determined using a multiplicative model and standardized to their respective means, 1959-1985 (Fig. 8 from Atkinson and Power, 1986).

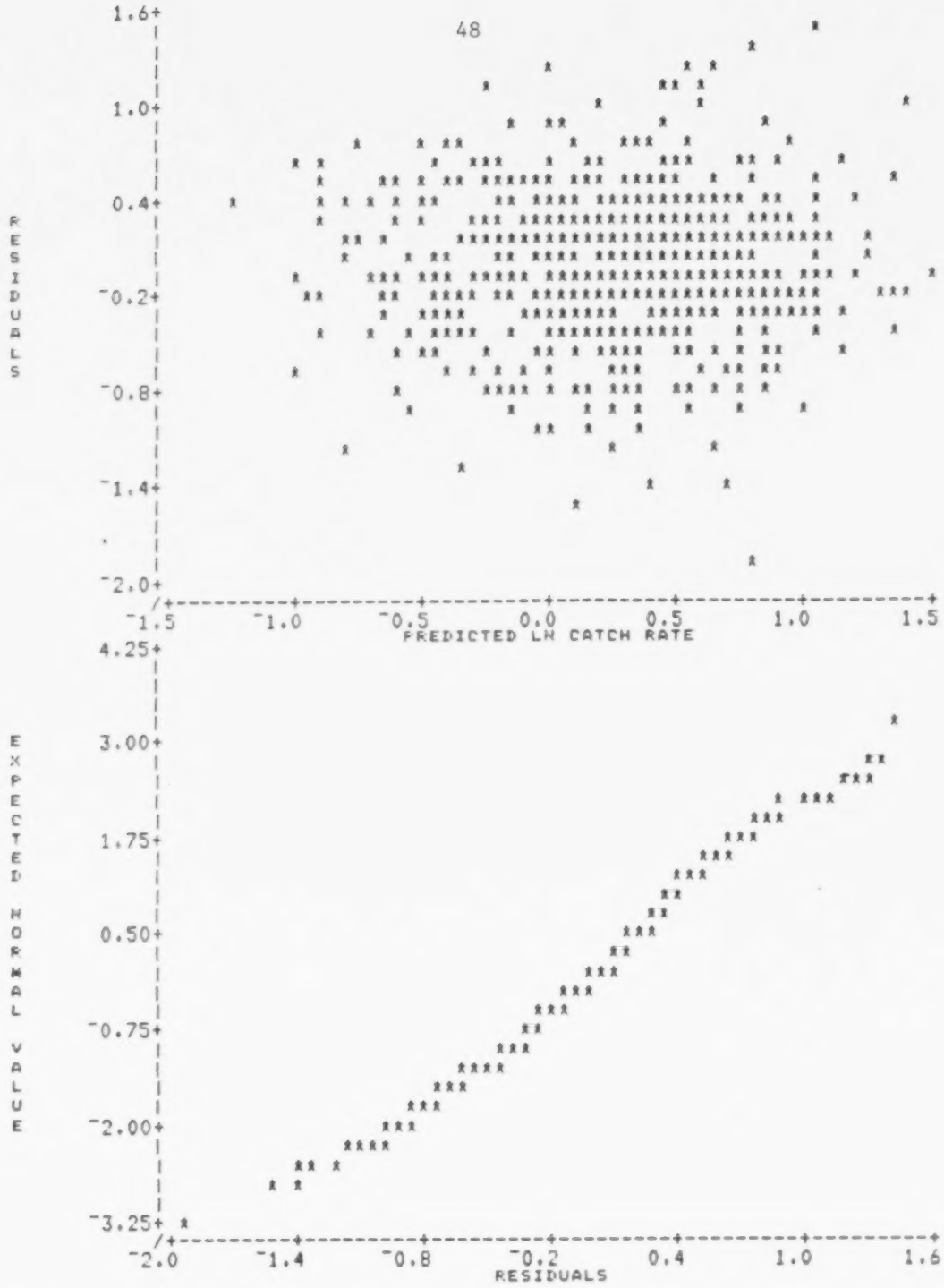


Figure 13. Plots of residuals versus predicted ln catch rate (upper) and expected normal versus residuals (lower) from the final multiplicative analysis of catch rate data.

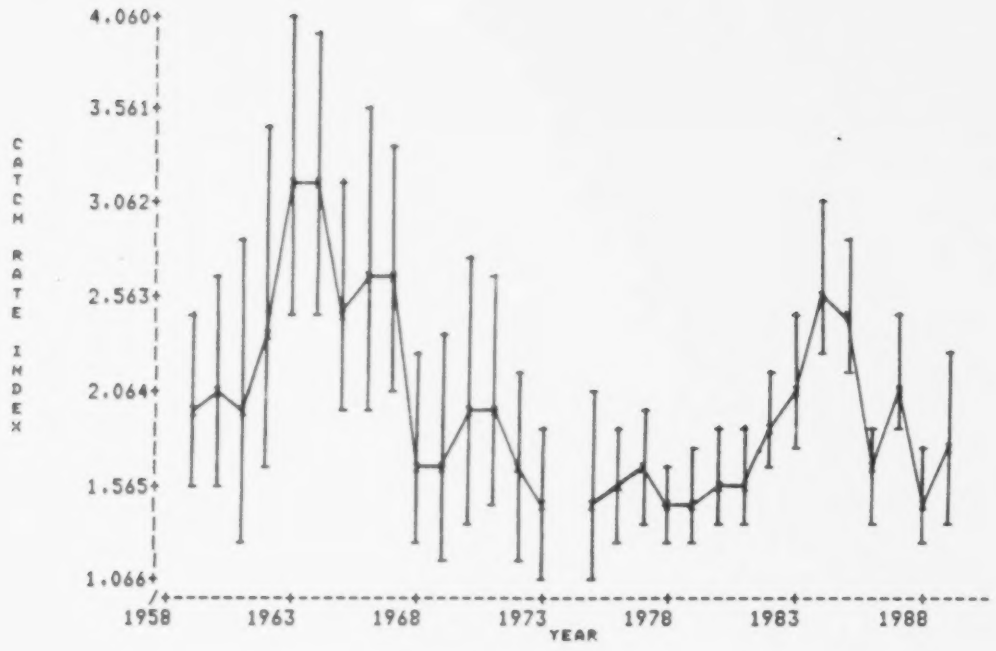
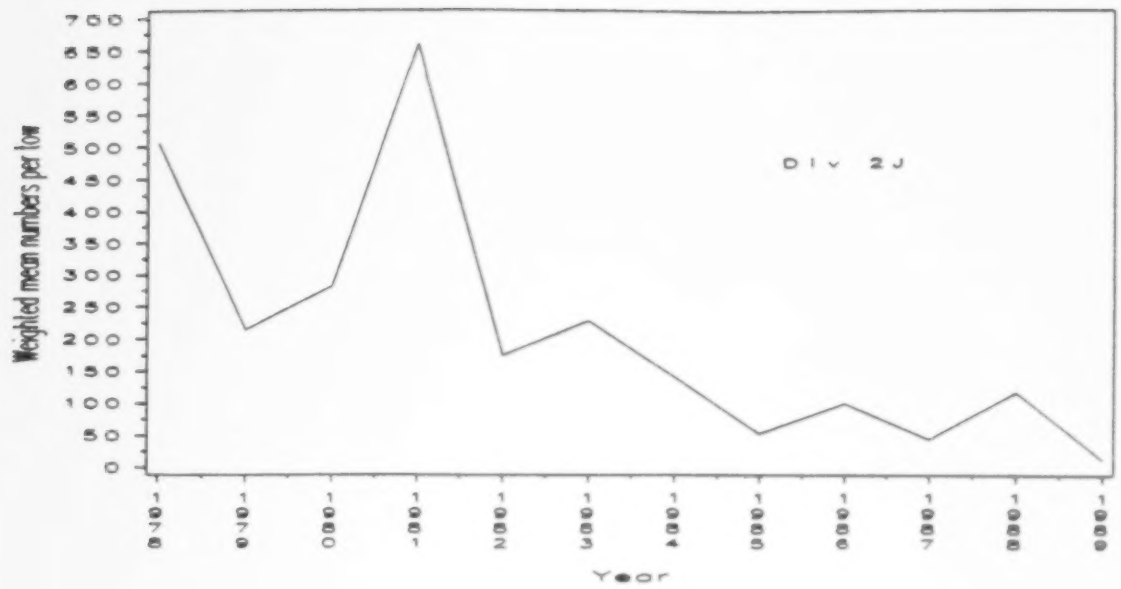


Figure 14. Standardized catch rate series from a multiplicative analysis of catch rate data incorporating a percentage of redfish category type (PCT) and excluding the 1974 data (see text).



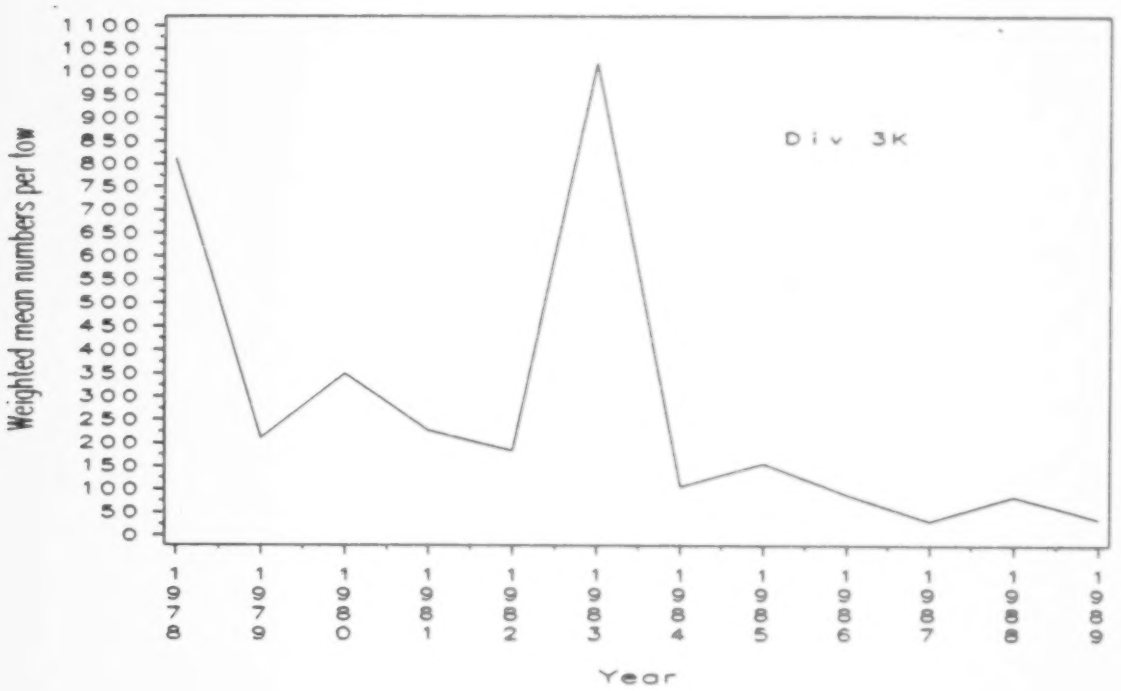
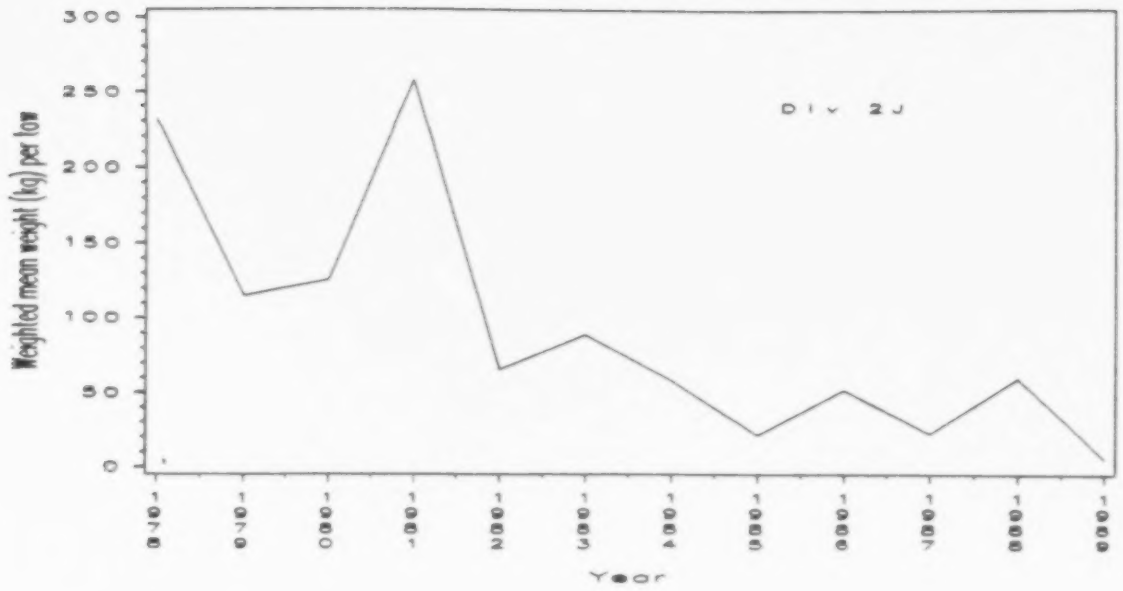


Fig. 15. Weighted mean per tow (numbers) in Div. 2J and 3K using a multiplicative model to fill in mean values in certain years in which various strata were not covered by the survey.



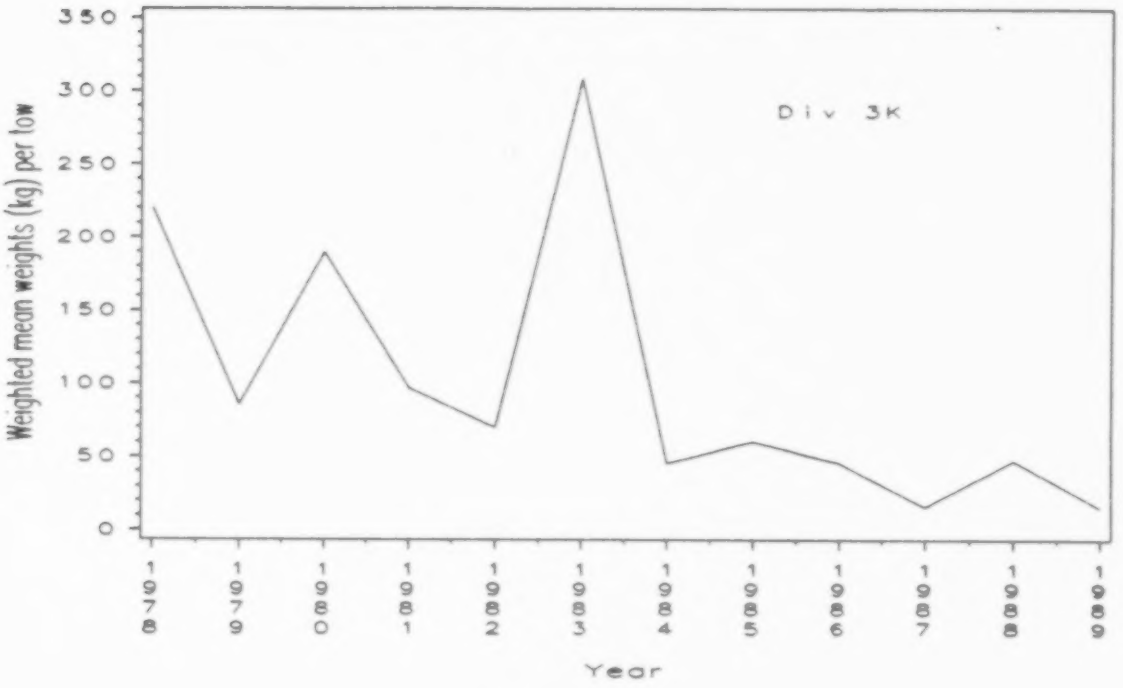


Fig. 16. Weighted mean per tow (weights) in Div. 2J and 3K using a multiplicative model to fill in mean values in certain years in which various strata were not covered by the survey.

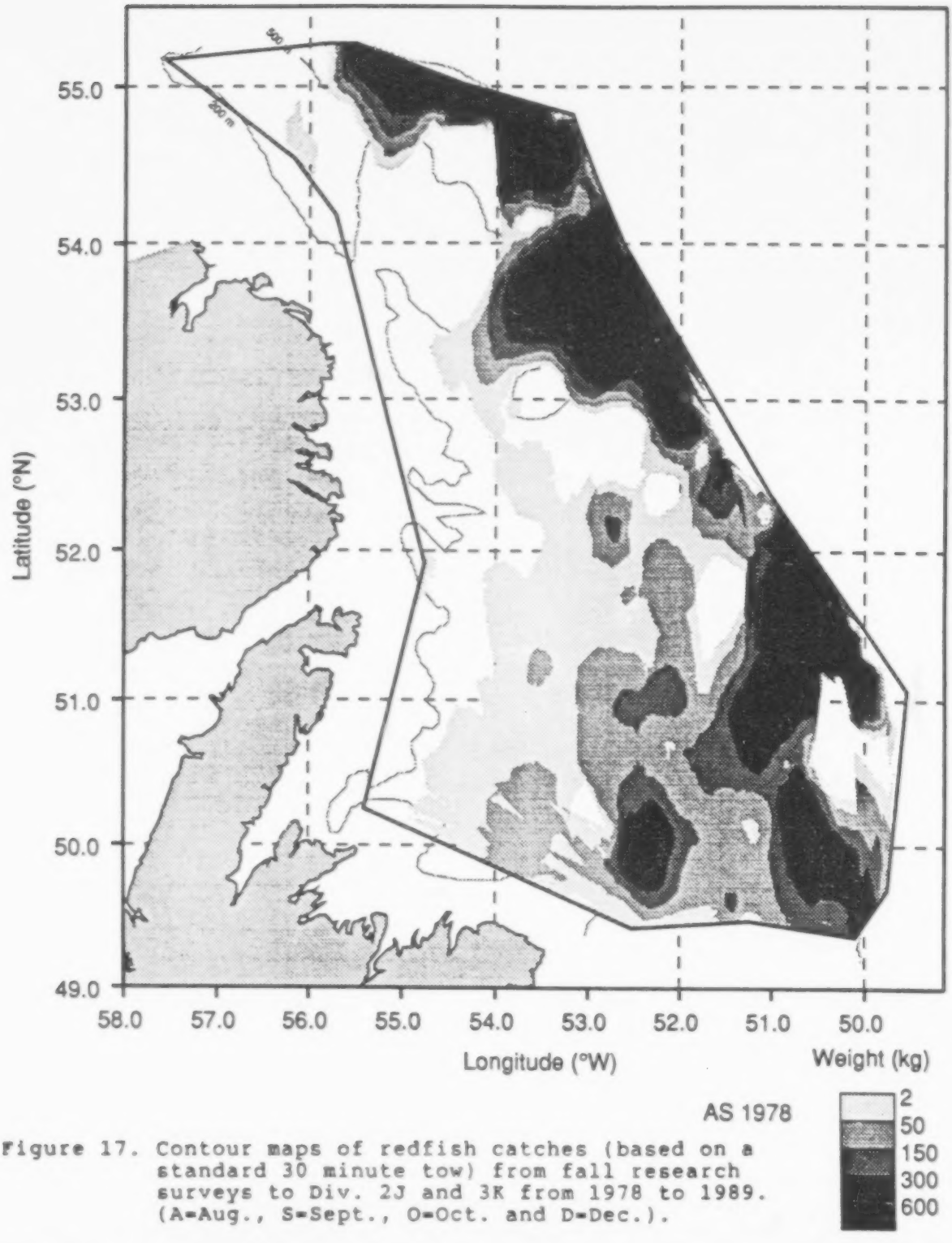


Figure 17. Contour maps of redfish catches (based on a standard 30 minute tow) from fall research surveys to Div. 2J and 3K from 1978 to 1989. (A=Aug., S=Sept., O=Oct. and D=Dec.).

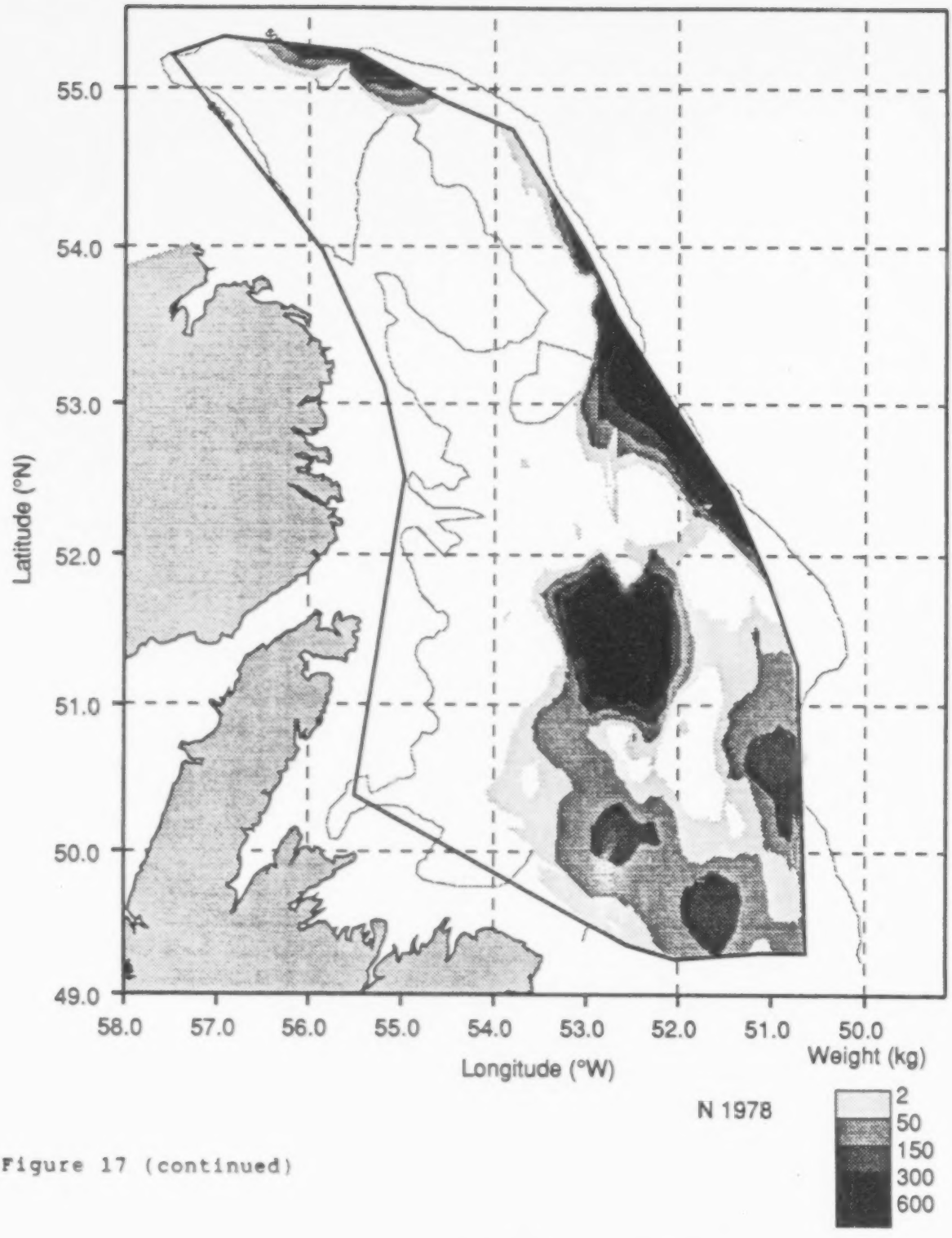


Figure 17 (continued)

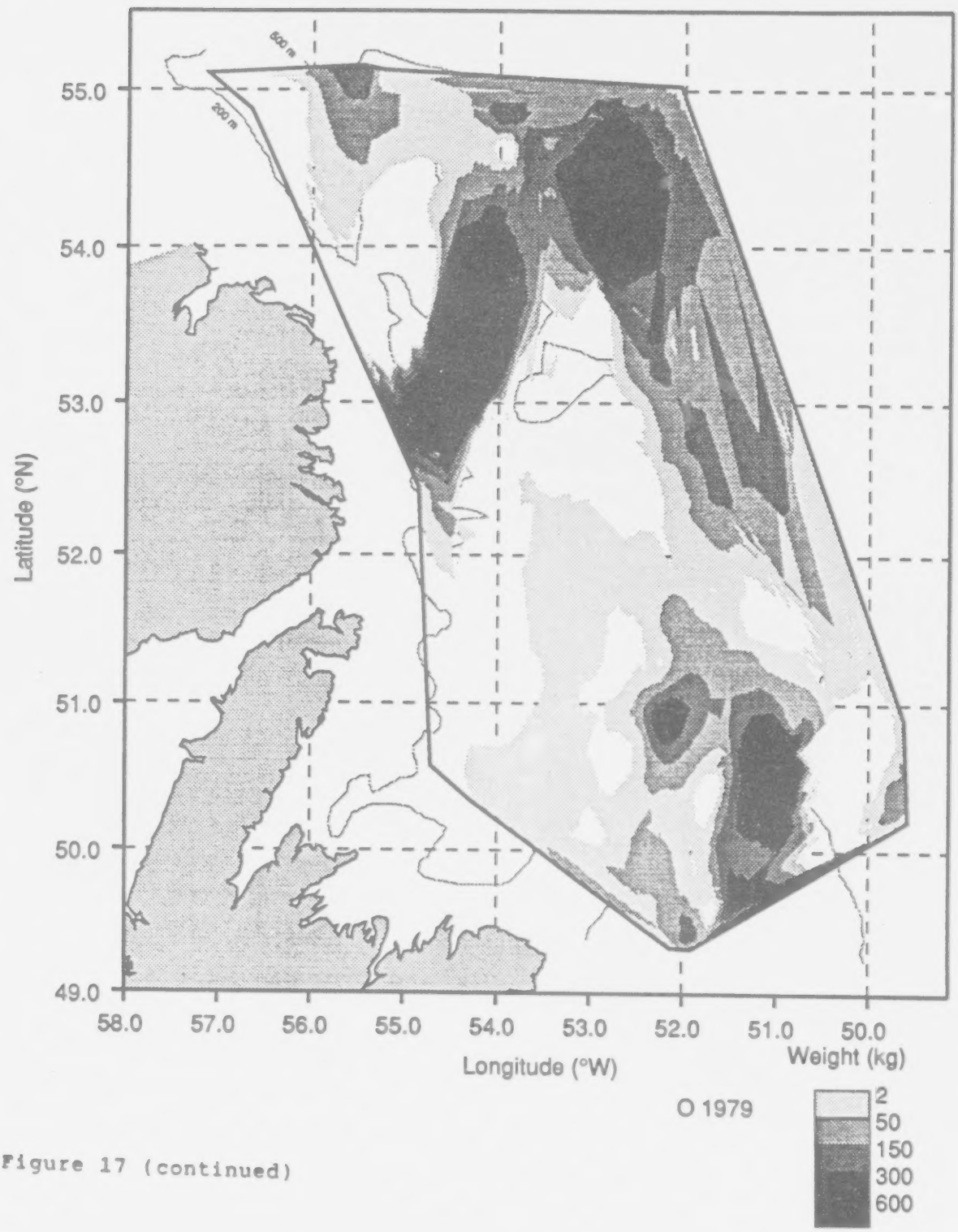
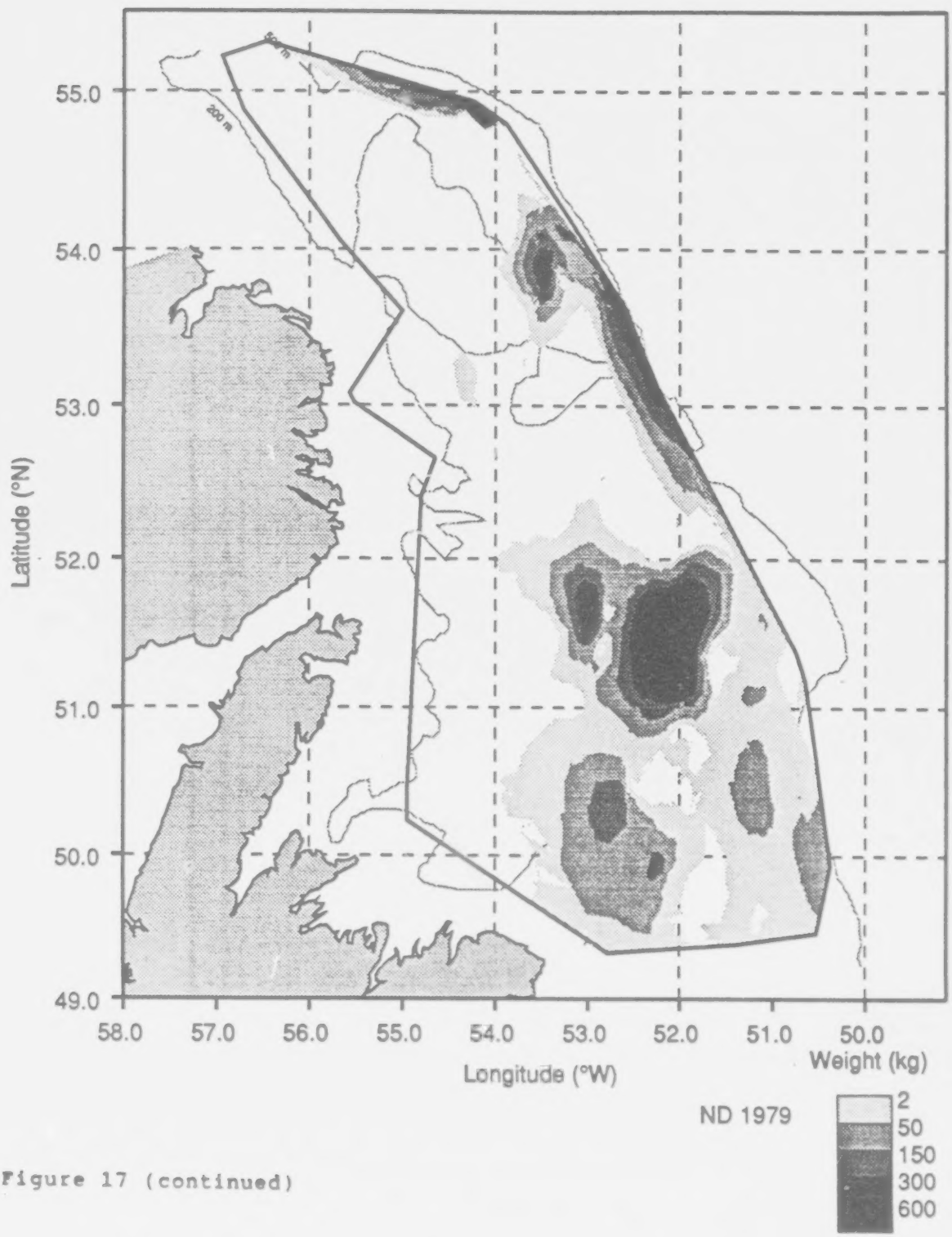


Figure 17 (continued)



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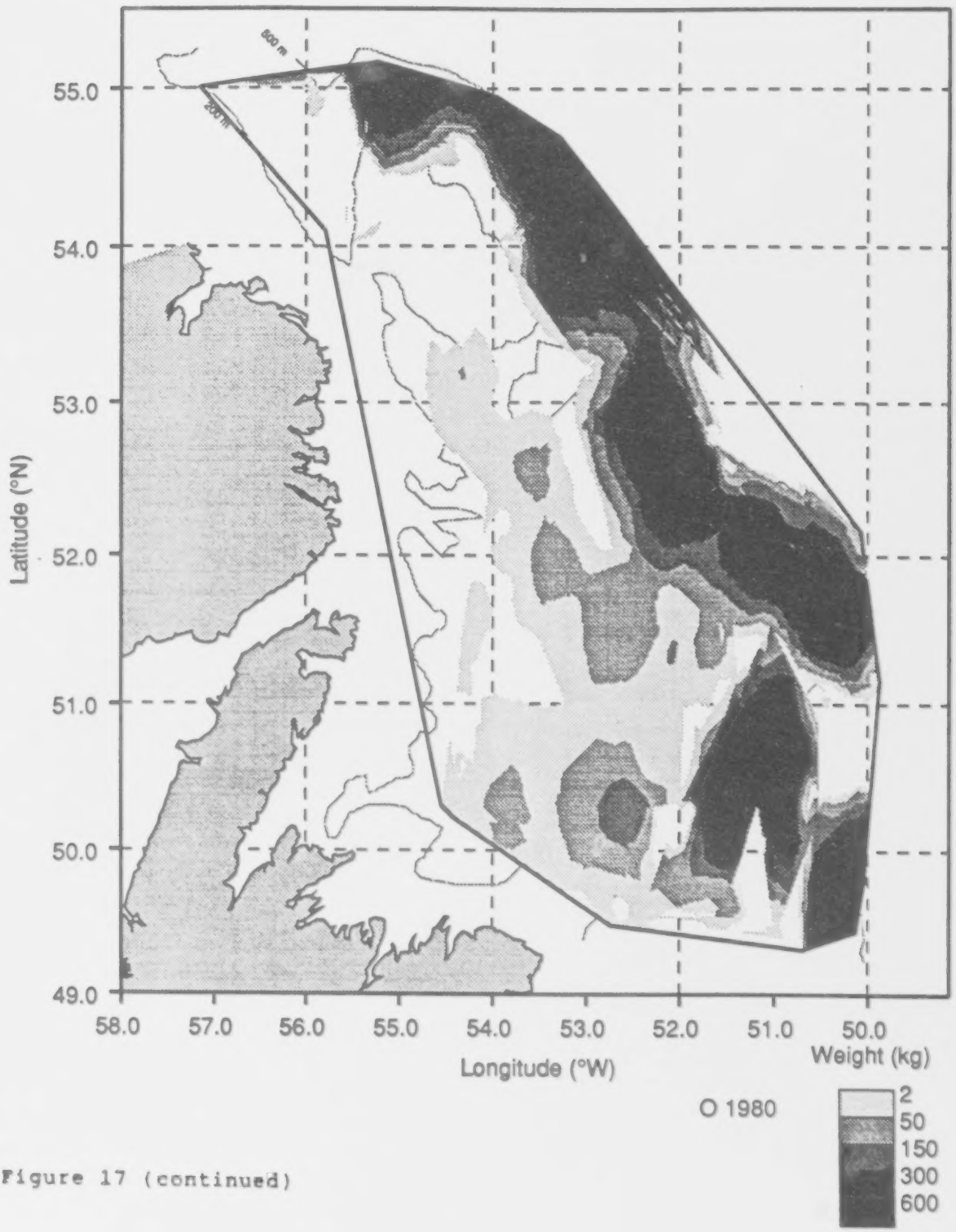

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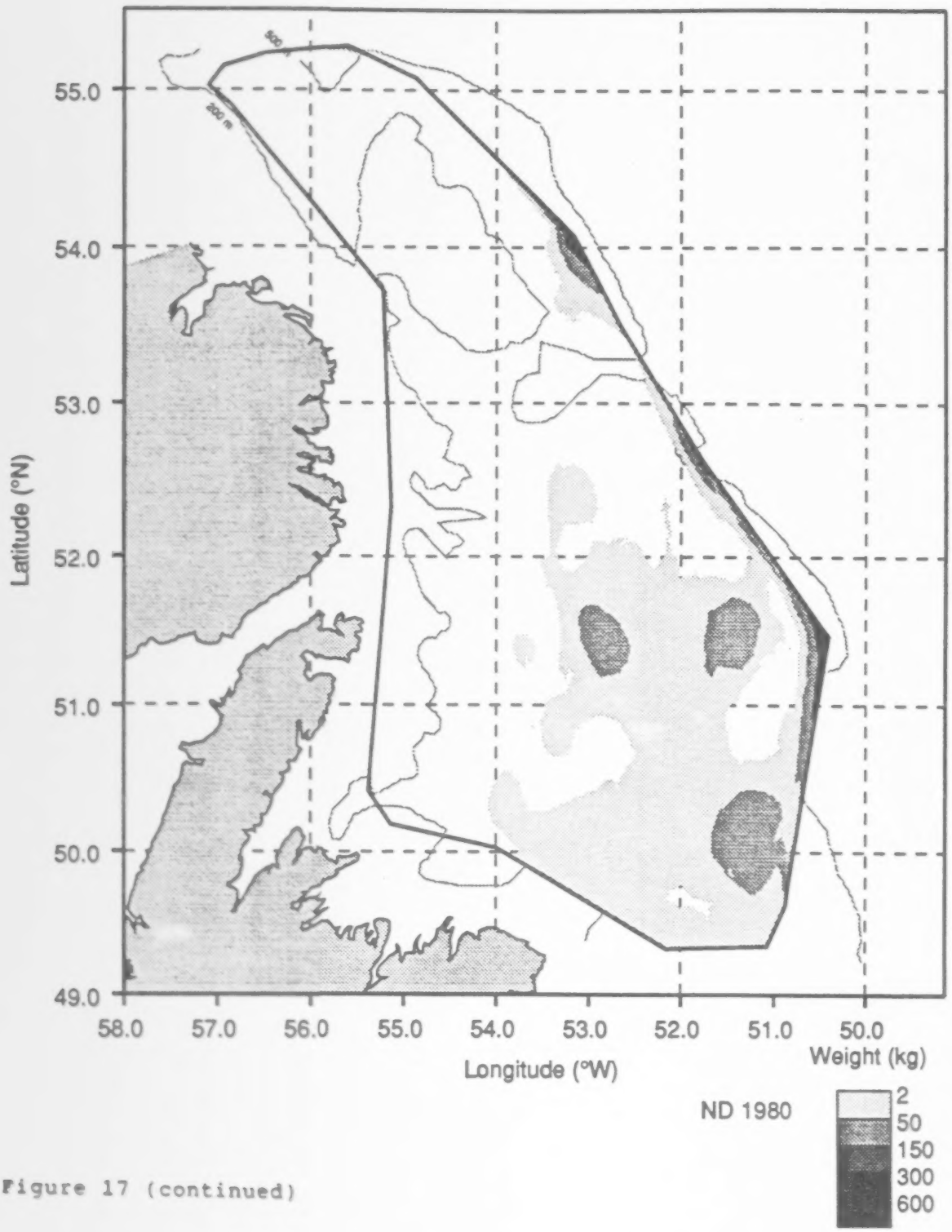

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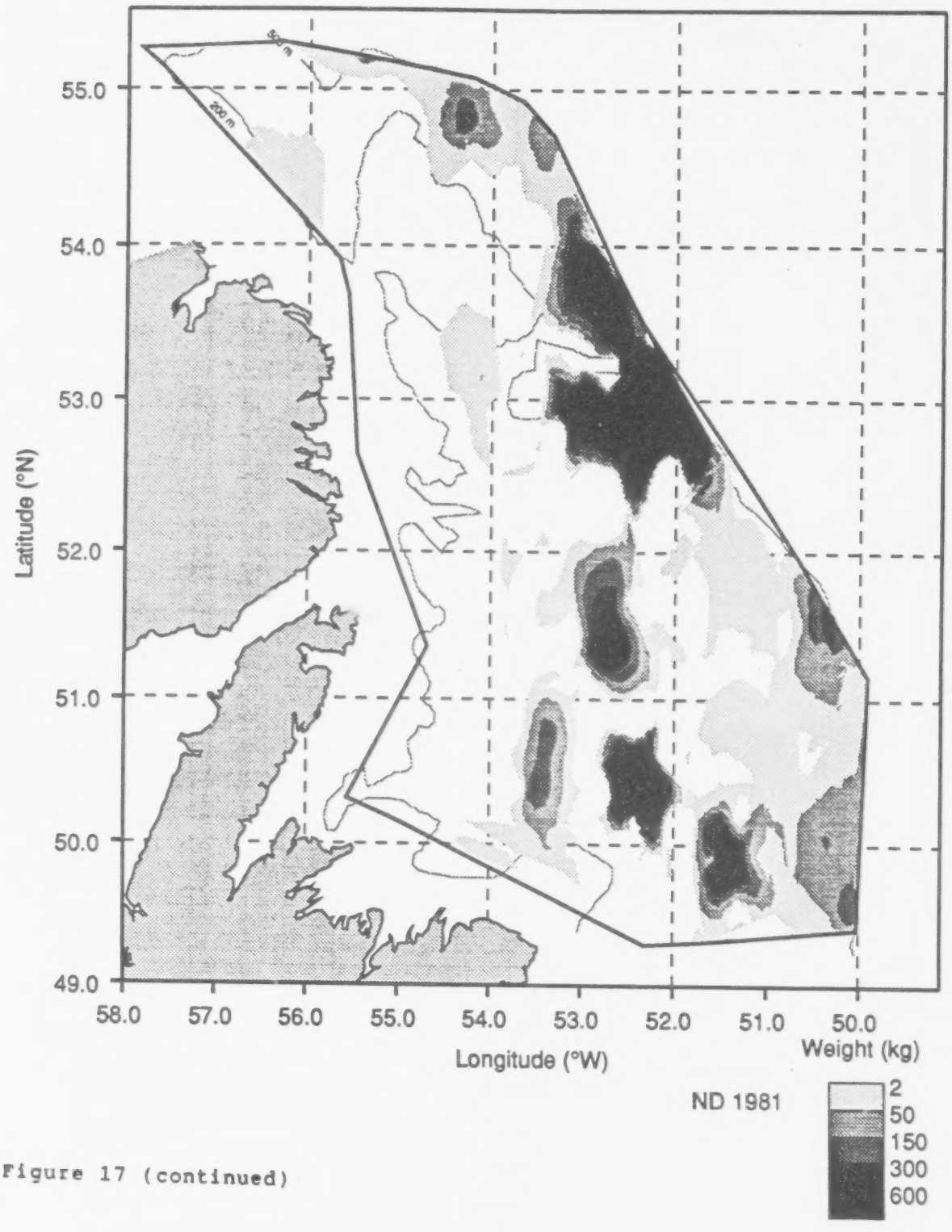
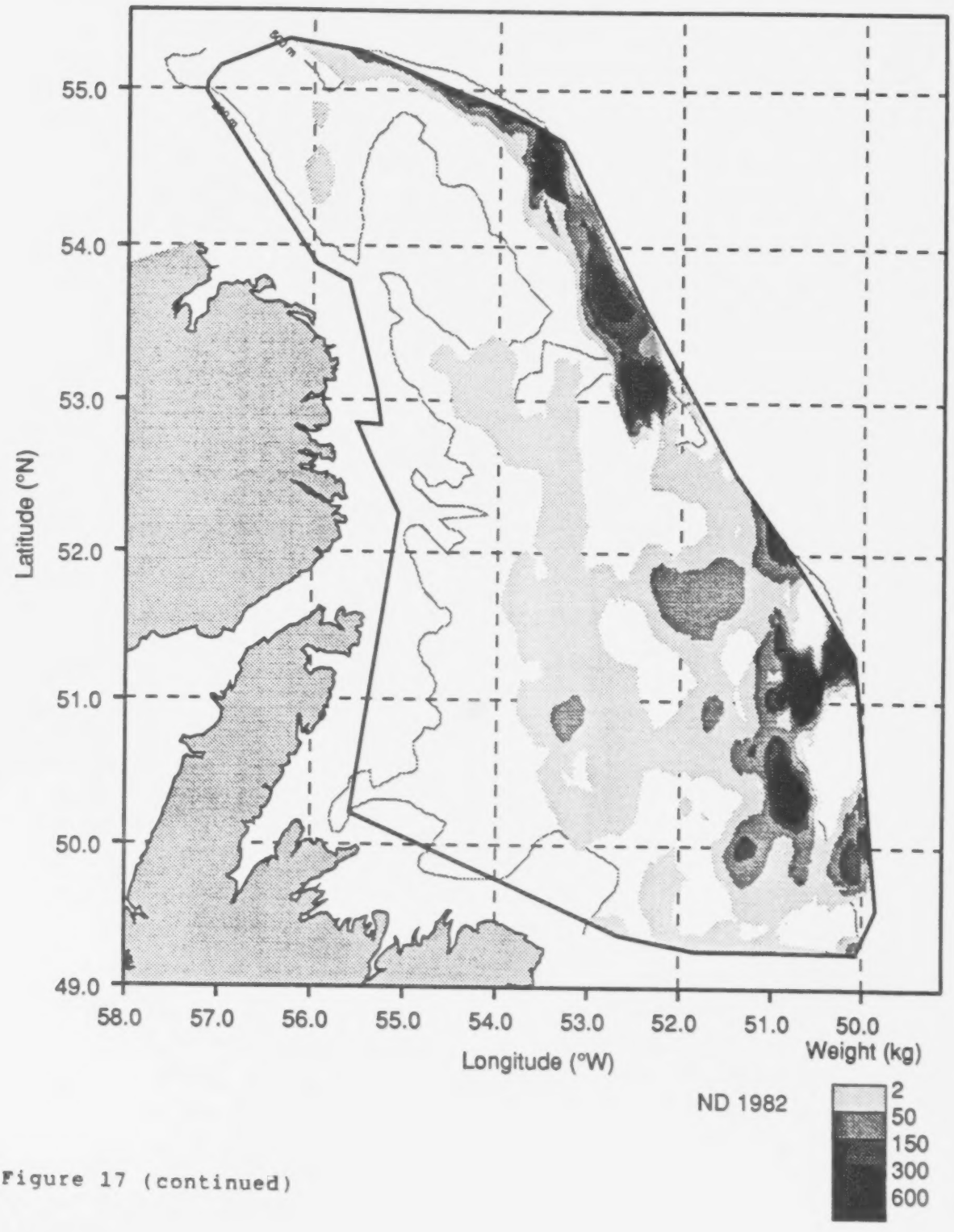


Figure 17 (continued)



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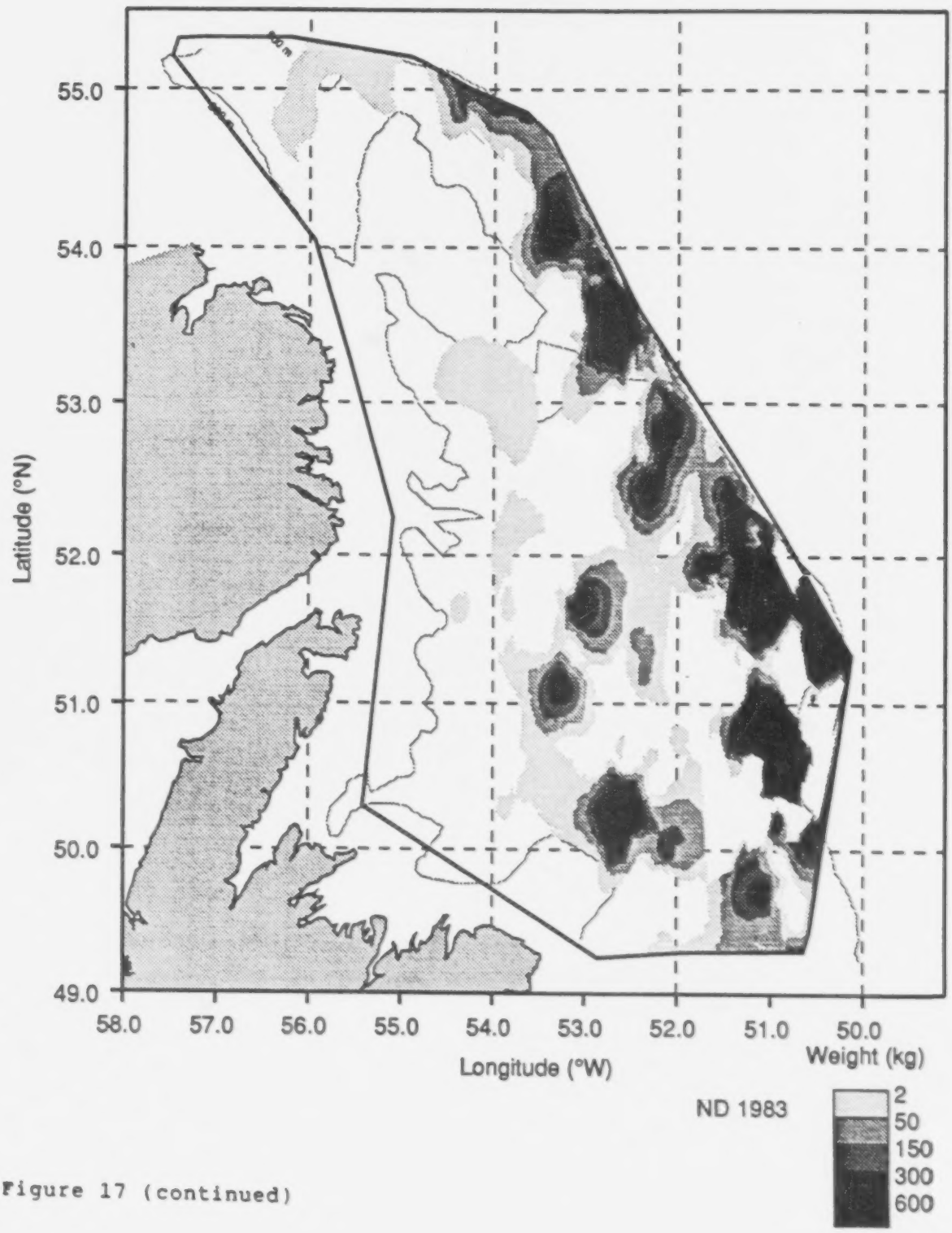

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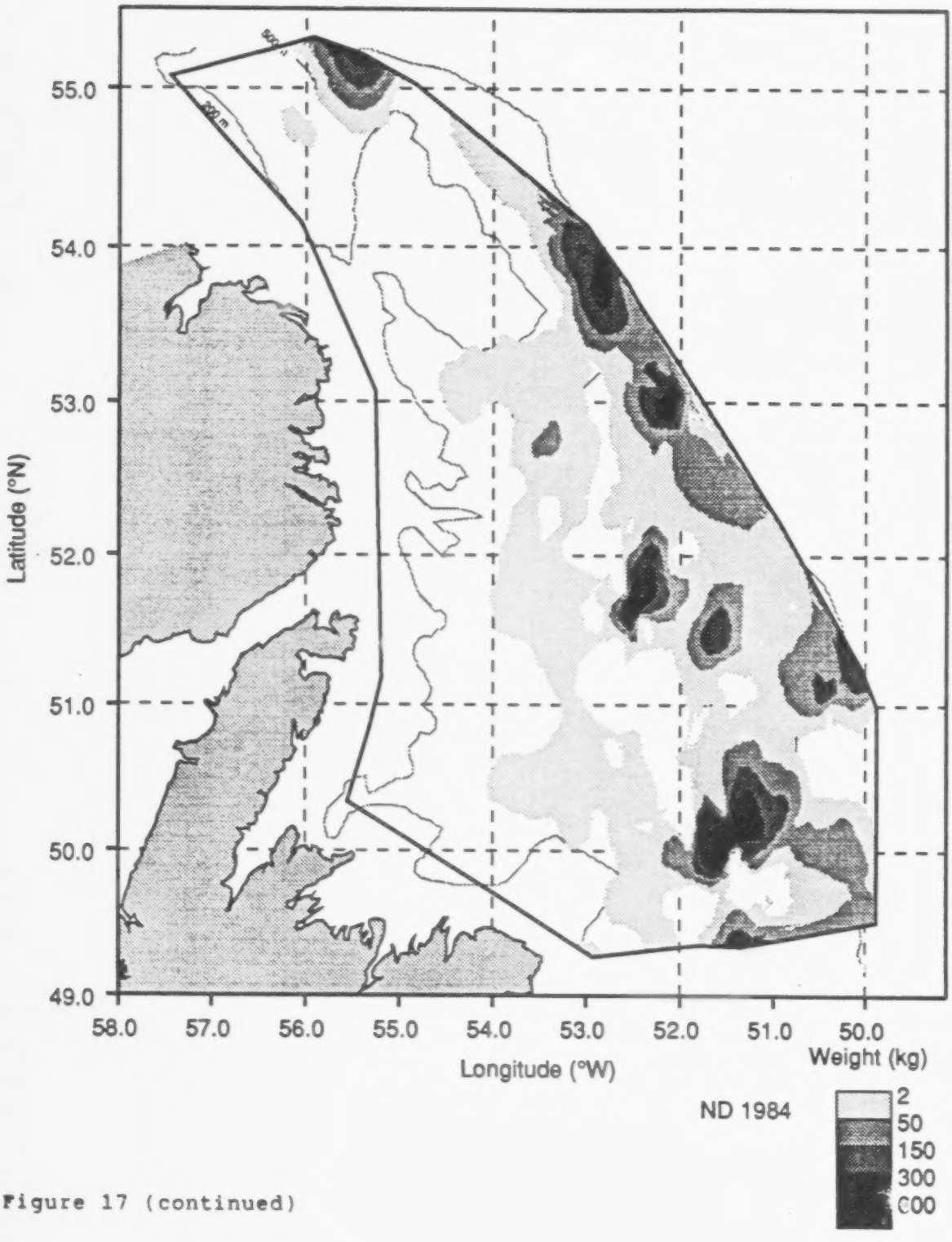

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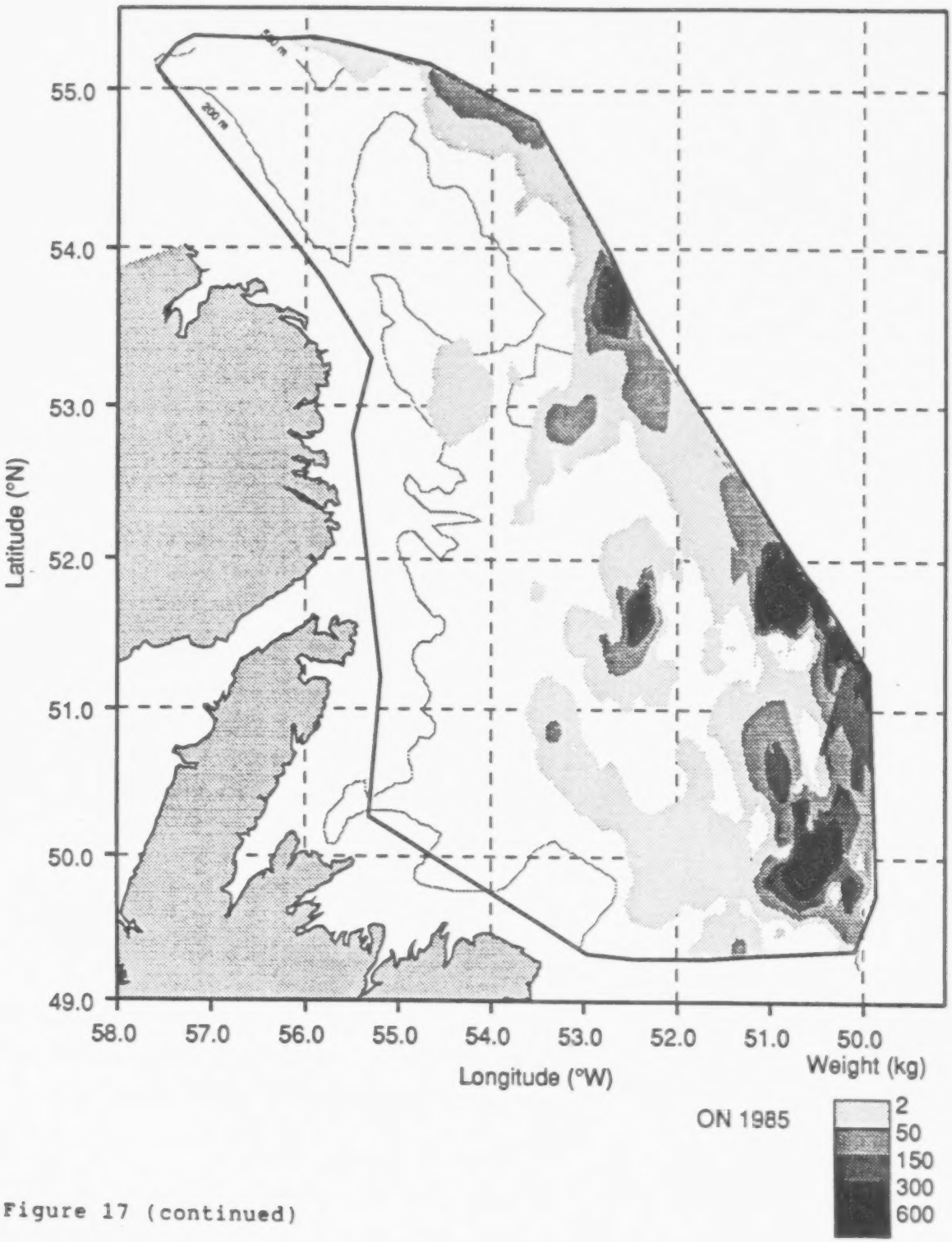

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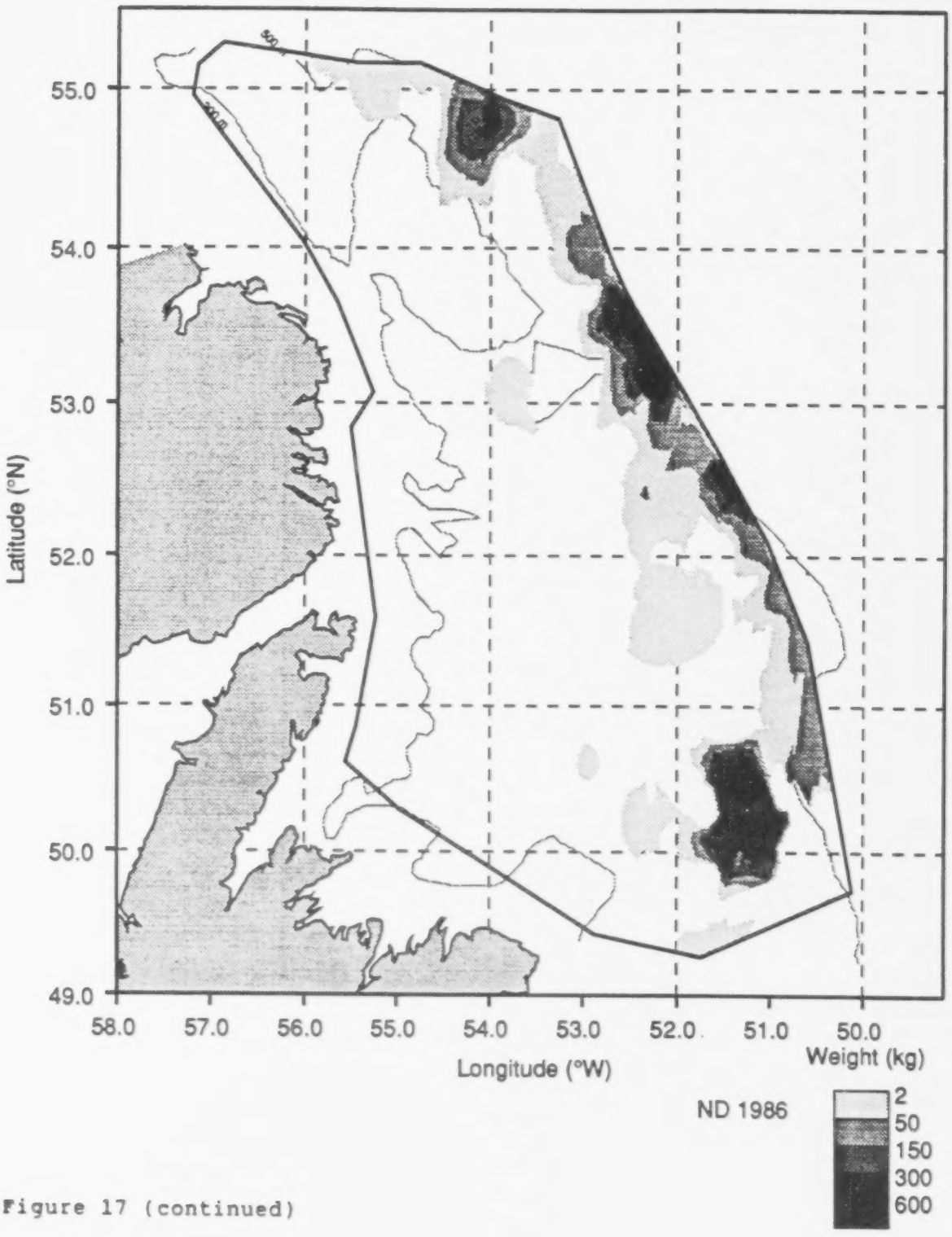

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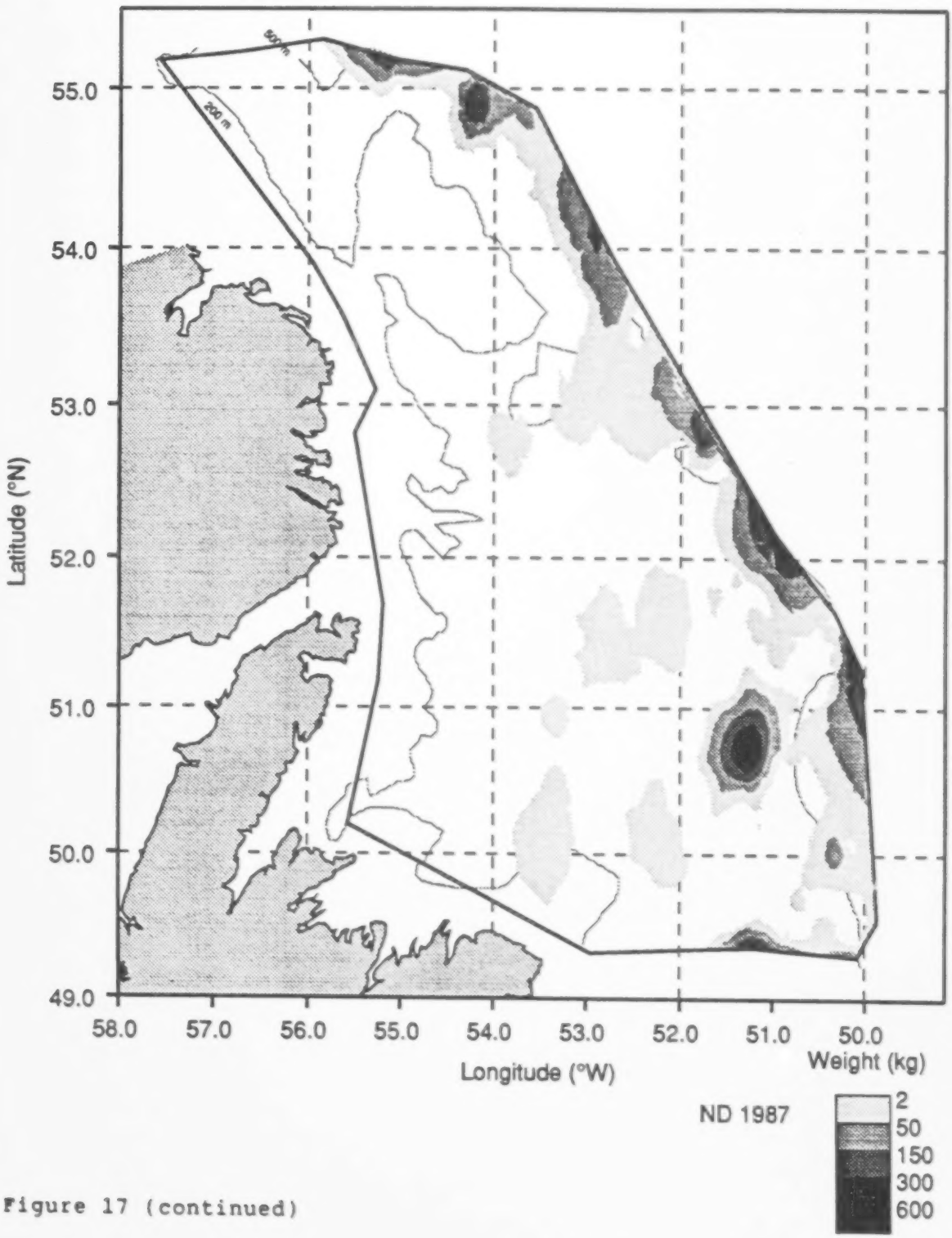

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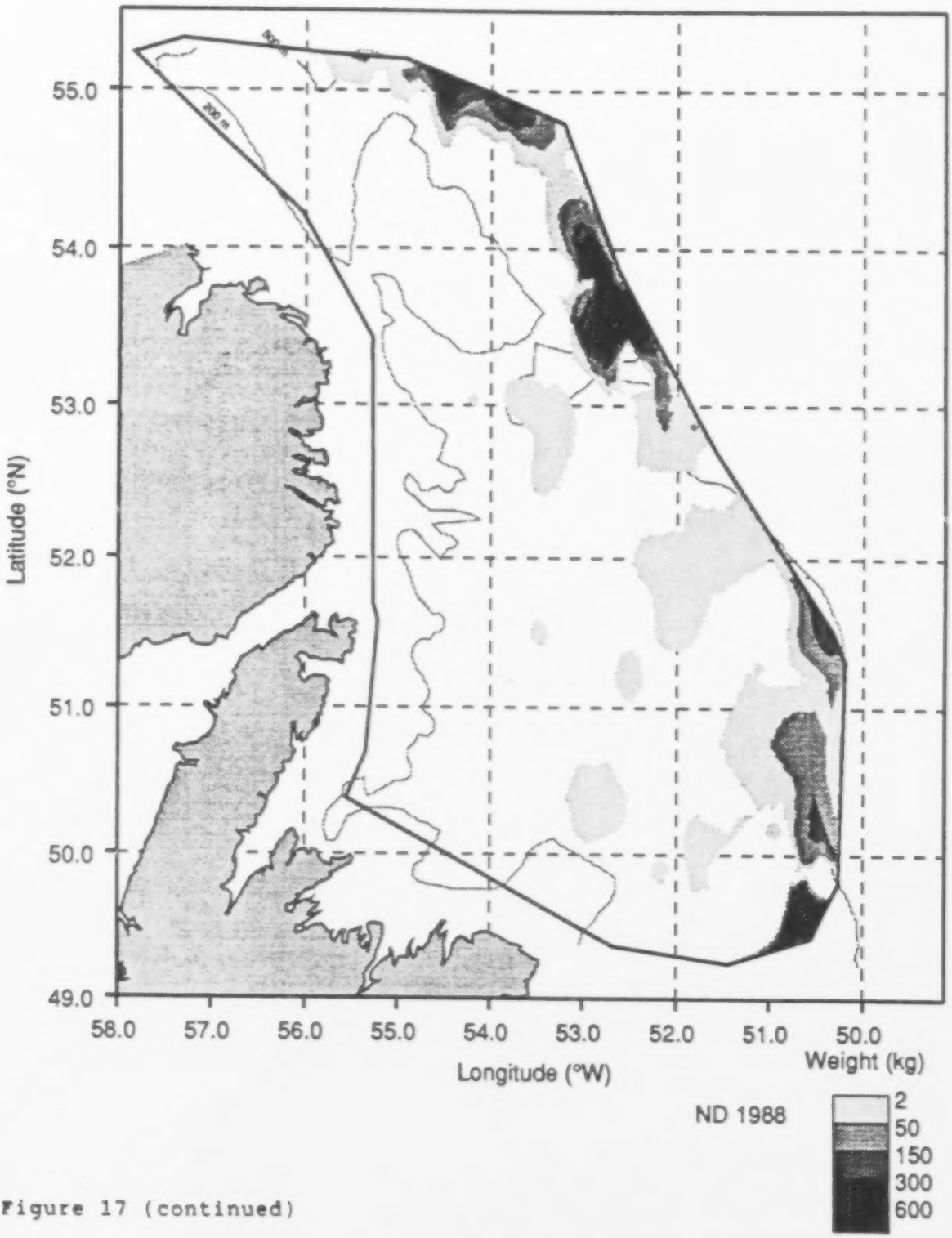

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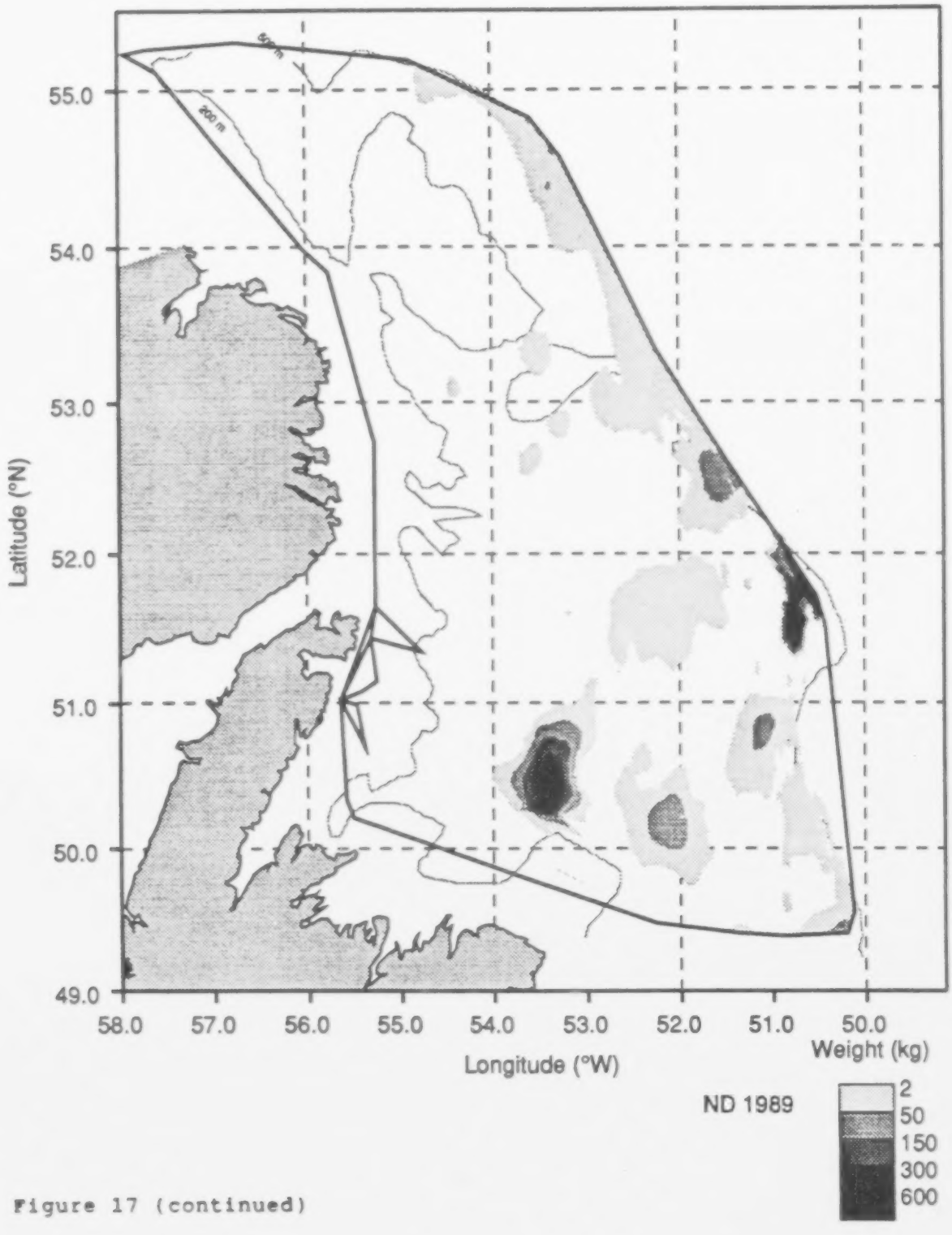

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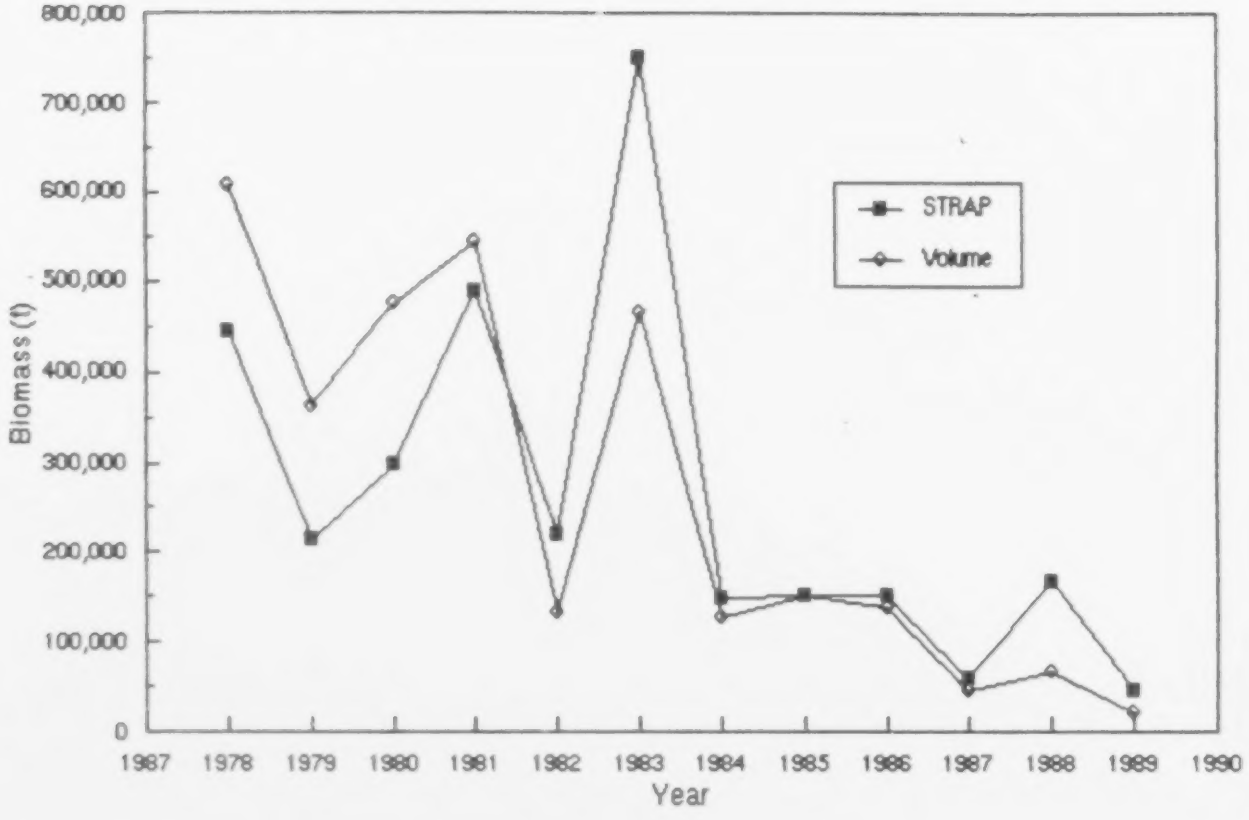

Figure 18. Comparison of trends in biomass estimated by areal expansion of stratum means (from STRAP) for each year as well as by a contouring algorithm (as used in the ACON contouring package).

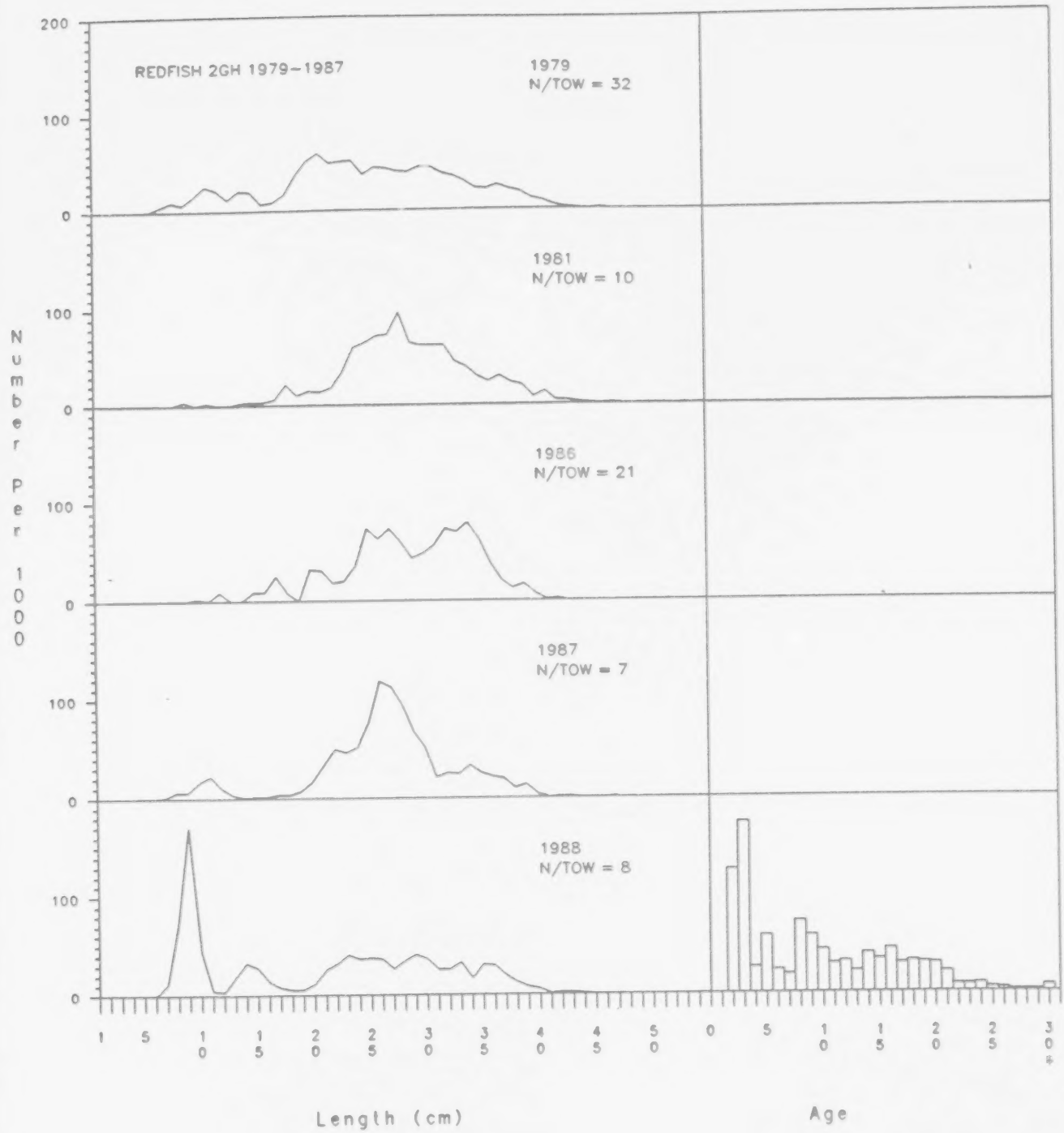

Figure 19: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2GH conducted since 1979.

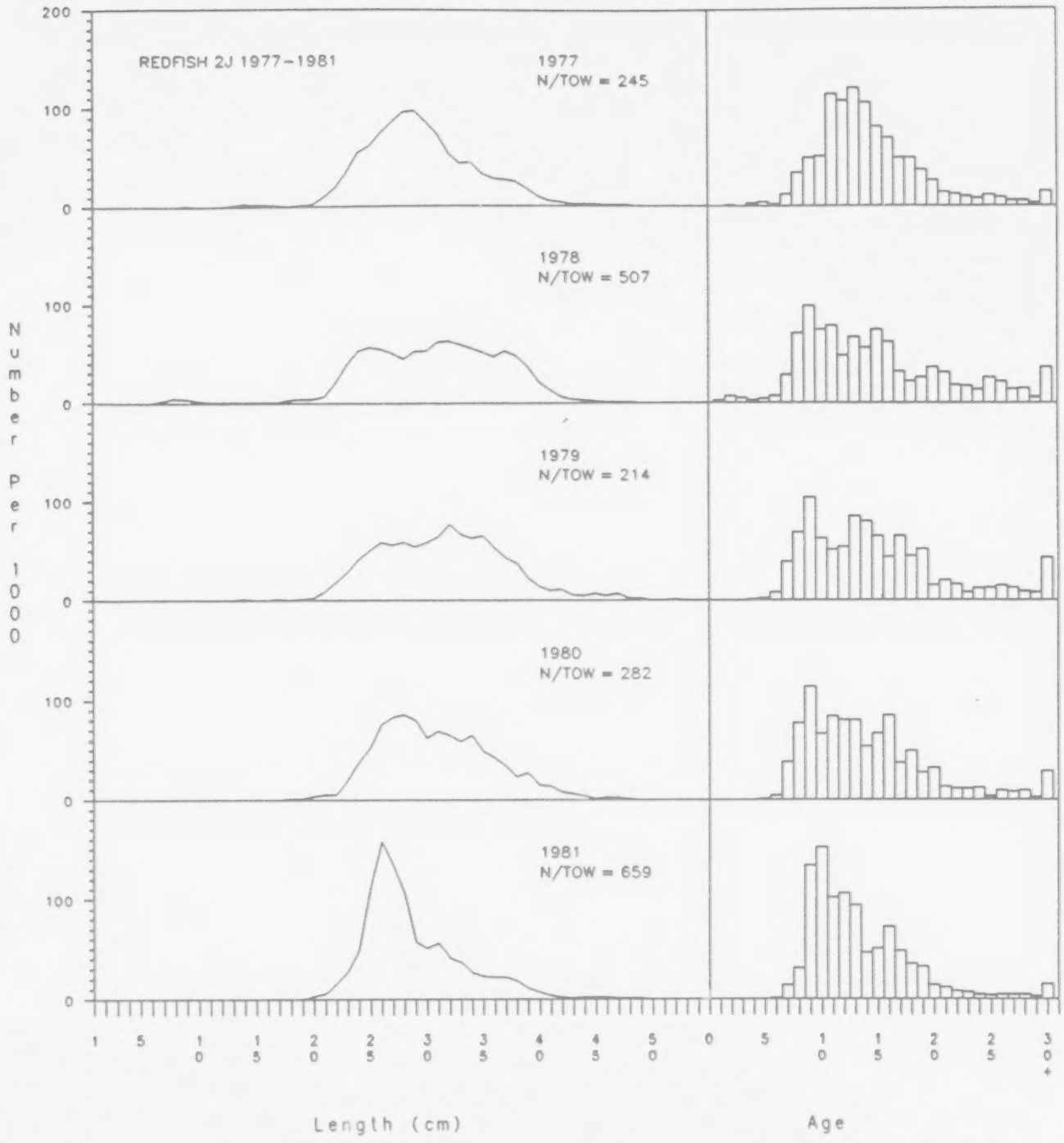

Figure 20: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1977-1981.

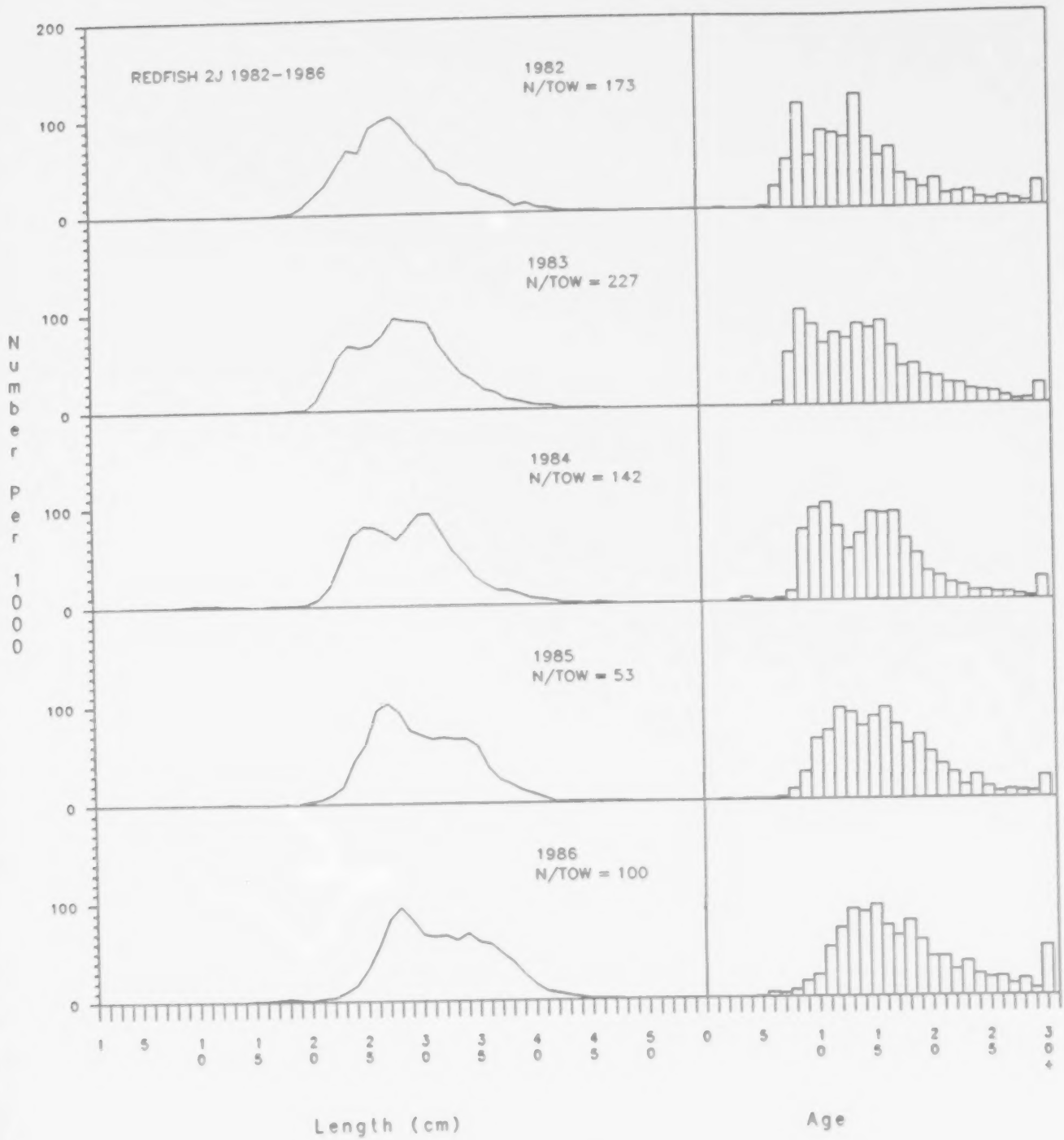

Figure 21: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1982–1986.

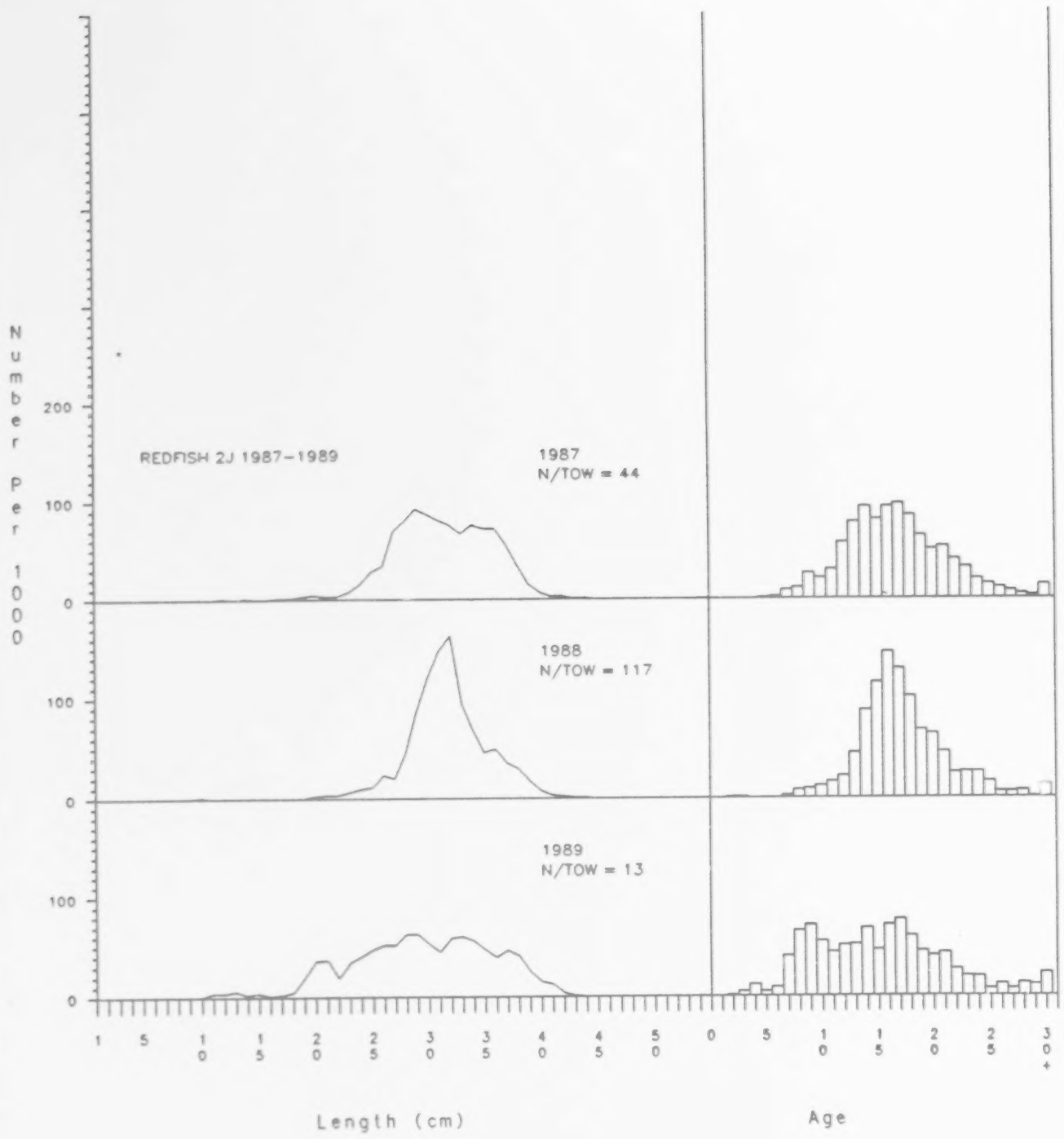

Figure 22: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1987–1989.

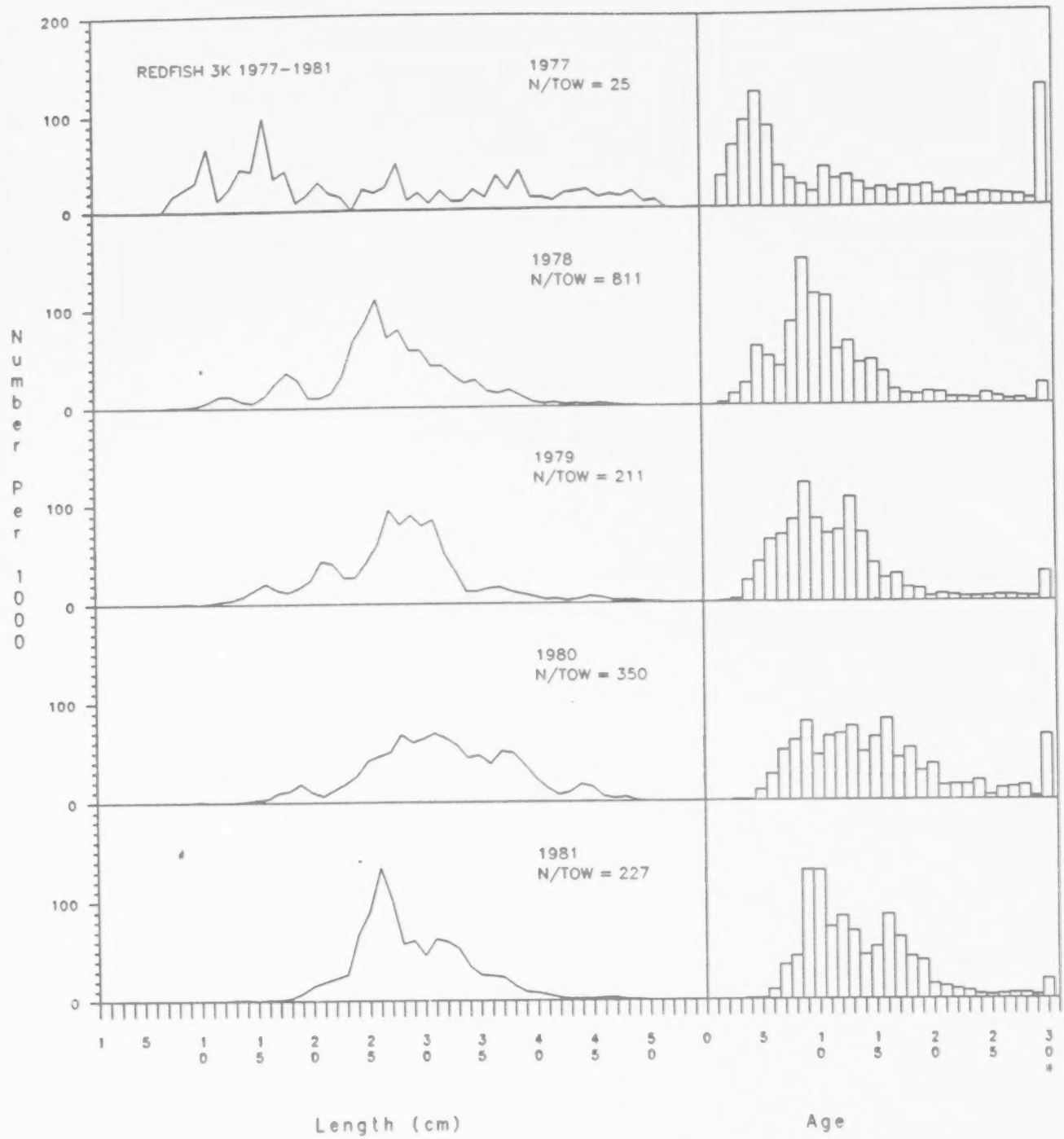

Figure 23: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1977-1981.

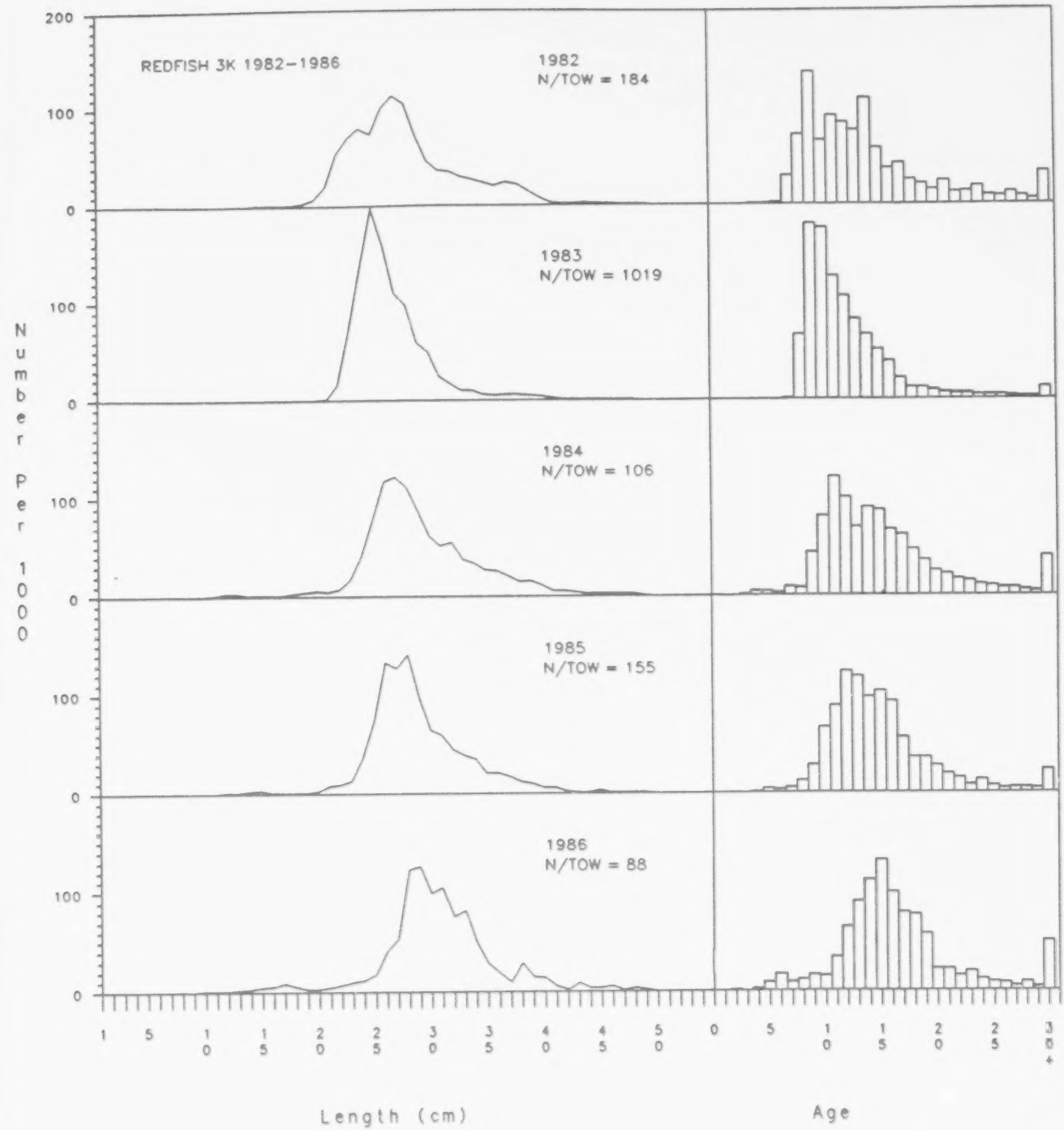

Figure 24: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1982–1986.

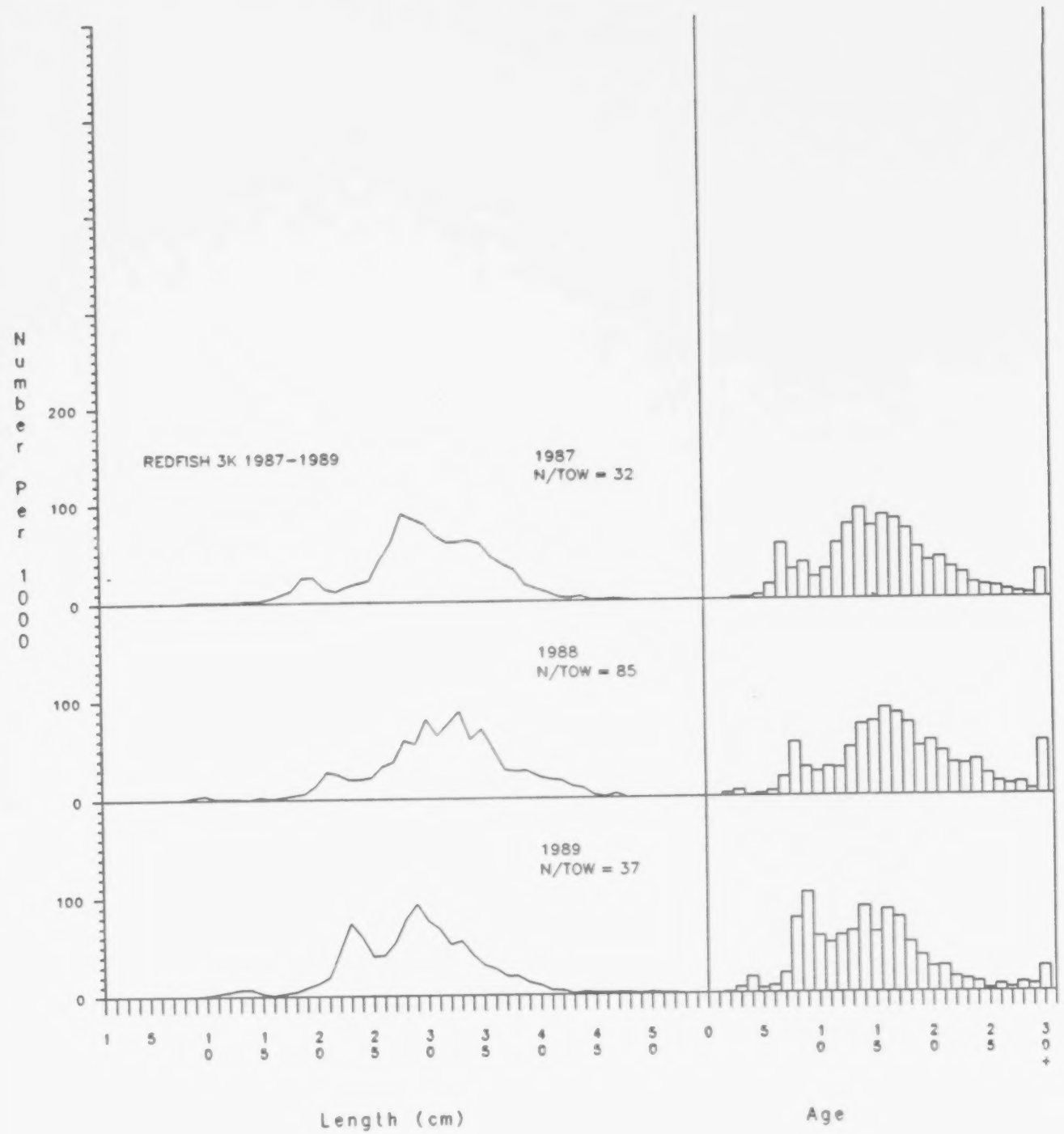

Figure 25: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1987-1989.

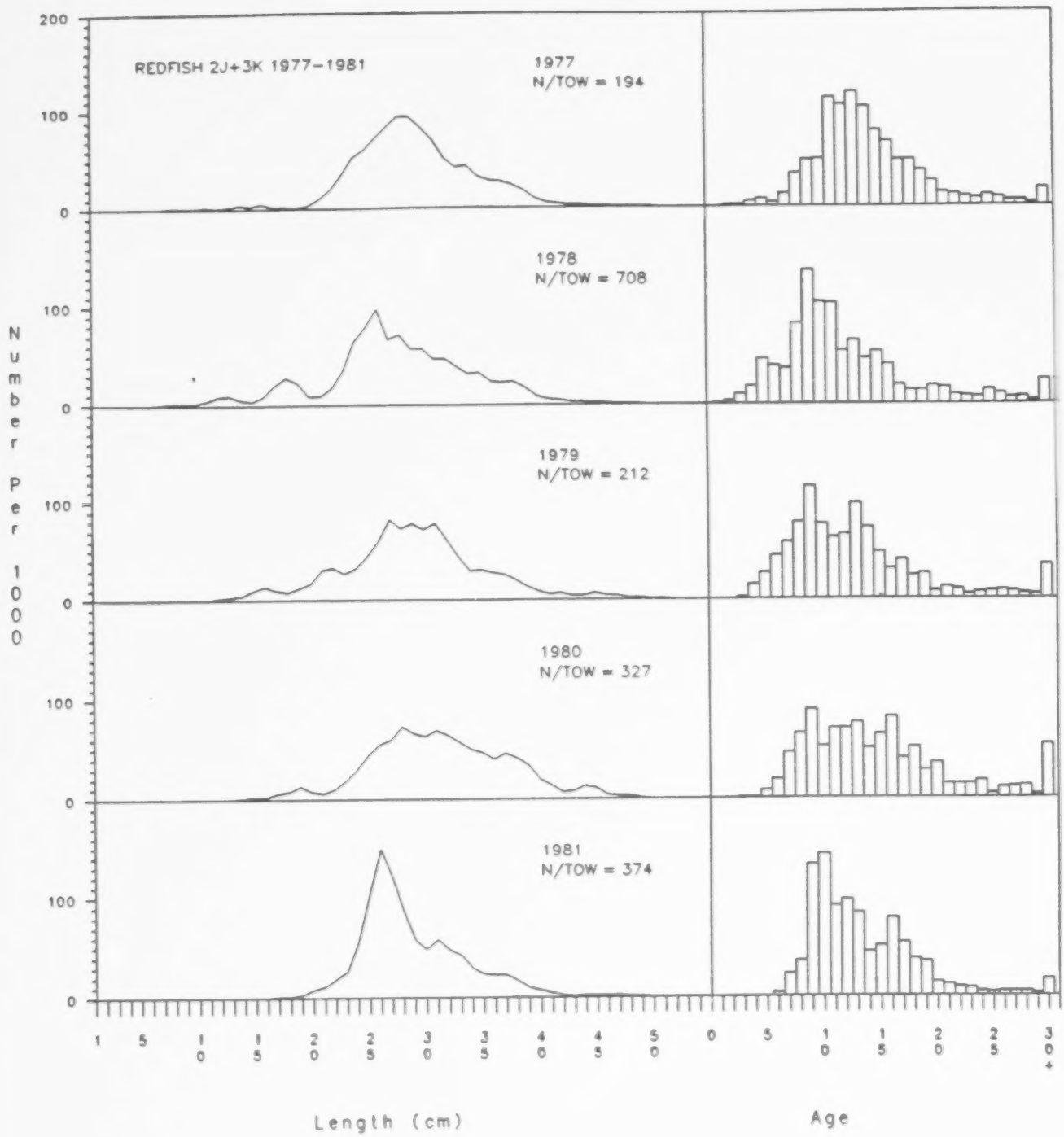

Figure 26: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1977–1981.

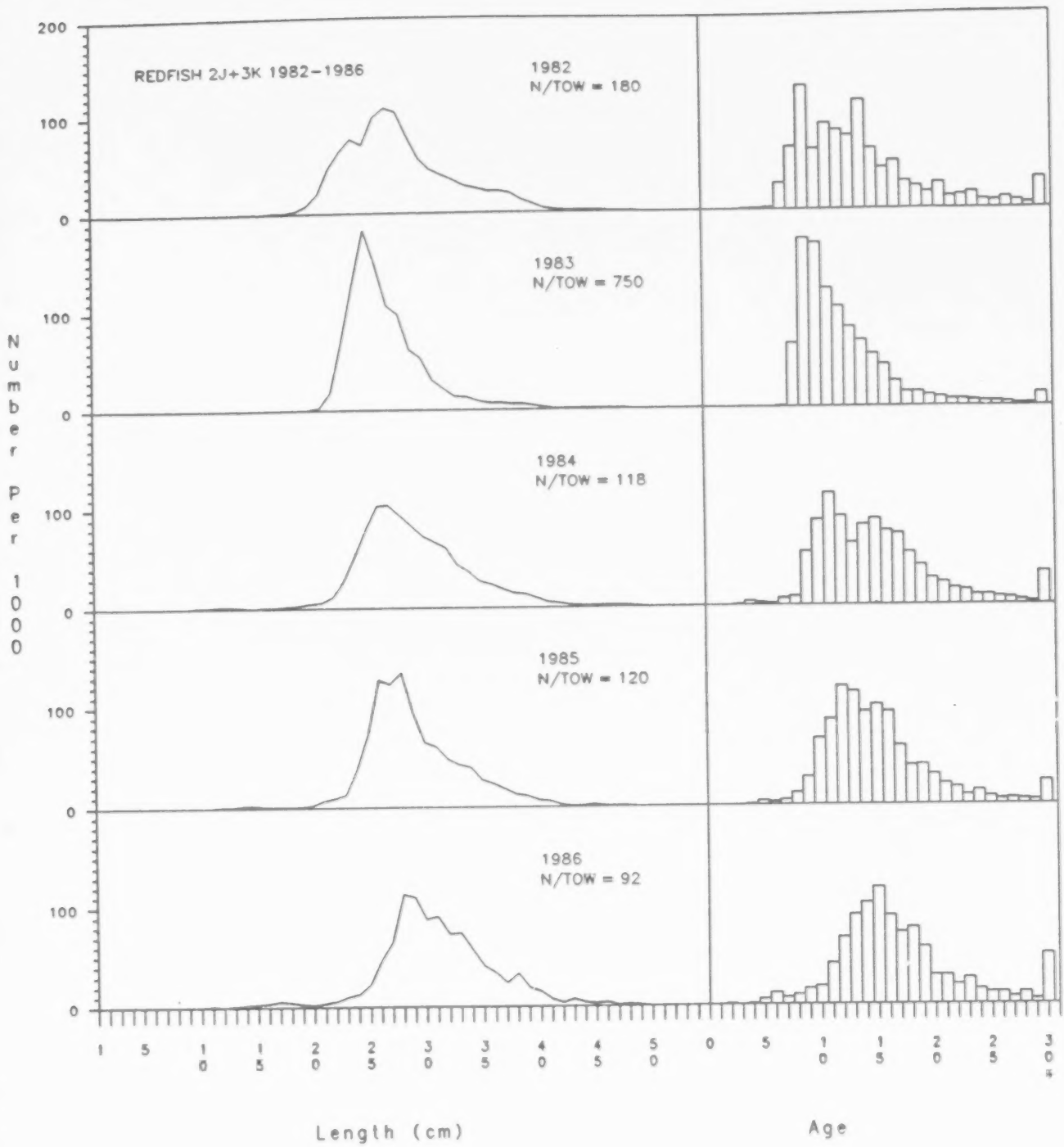

Figure 27: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1982-1986.

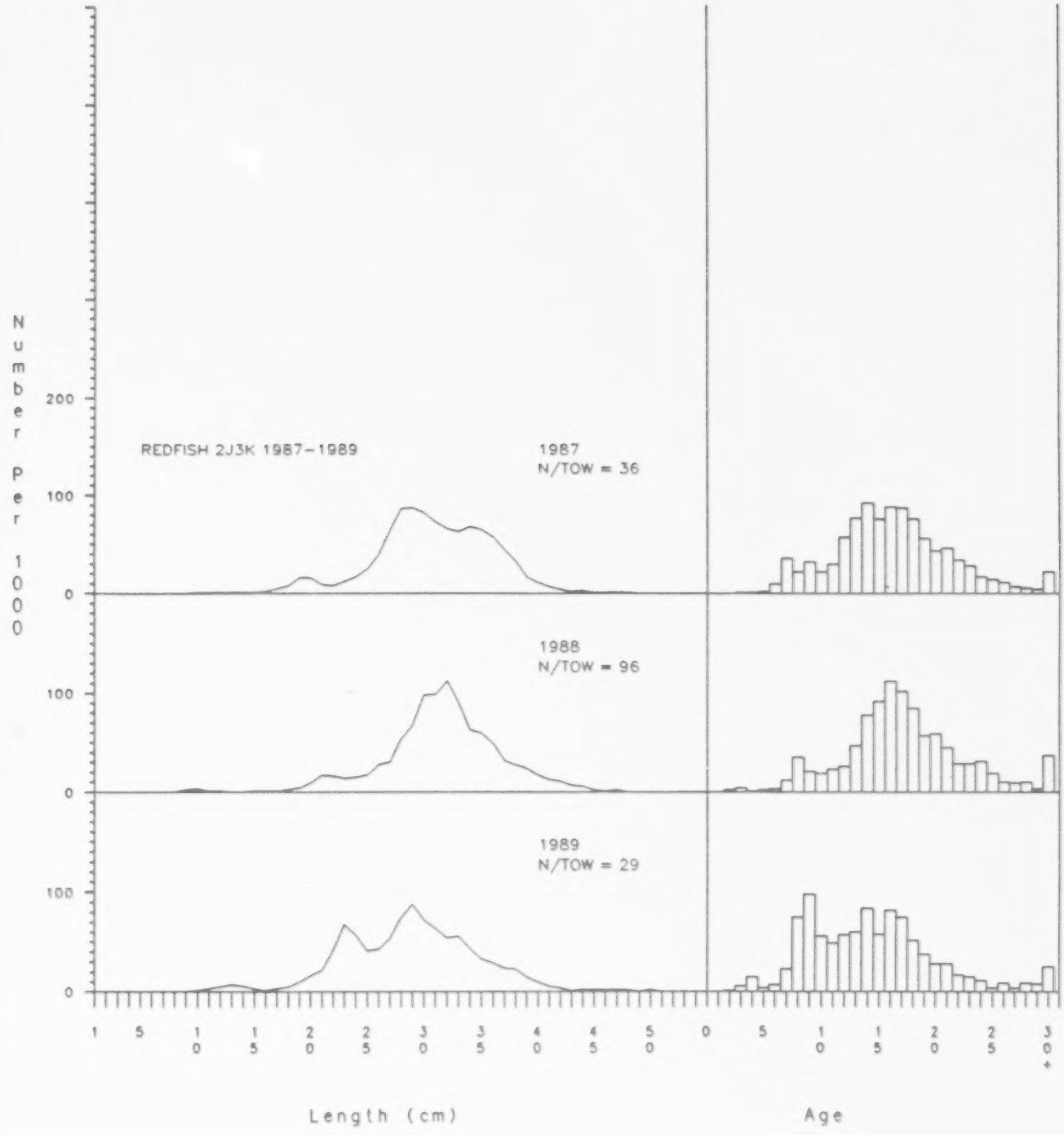

Figure 28: Redfish length frequencies and corresponding age distribution from stratified random research surveys in Div. 2J3K for the years 1987-1989.